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JOURNAL OF GERONTOLOGY

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EFFECT OF AGE ON ENZYMIC RELEASE OF AMINO ACIDS FROM AORTA TISSUE

WILLIS A. GORTNER, Ph.D.

(From the Bjorksten Research Foundation, Madison, Wisconsin[1])

MANY workers have noted that the elasticity and imbibition capacity of tissue proteins such as muscles (10) and arteries are greatly altered by aging, but the fundamental reactions involved in this basic phenomenon of aging are still unknown. Bjorksten (2) has postulated that cross-linking of tissue proteins leading to altered physical properties and to resistance to metabolic turnover may be a basic cause of physiologic aging. The present study was undertaken (a) to obtain information on the amino acid makeup of tissue proteins as affected by age as an indicator of a possible shift from one protein to another during aging, (b) to study a possible shift in the types of links in the proteins by observing the effects of different proteolytic enzymes having different degrees of effectiveness in splitting the various bonds found in proteins, and (c) to evaluate the efficiency of various enzymes in effecting a reversal of intermolecular or intramolecular cross-linking.

A few studies (5, 6) have indicated that the amino acid composition of arterial elastin changes with age. In particular, attention has been called to an increase in the dicarboxylic acids of aorta elastin with age, a change which was not observed in the elastin of the pulmonary artery, which is generally free of sclerotic degeneration in contrast to the aorta. The data (6) indicate, however, that the altered composition is not confined to the dicarboxylic acids, since apparent increases of similar magnitude (1.7 to 5.8 fold) were observed for lysine, arginine, histidine, cystine, methionine, tryptophan, serine, and threonine. Glycine seemed to decrease with age.

To ascertain whether such changes in the makeup of one of the principal proteins in the arterial wall result in altered susceptibility to proteolysis of the aorta tissue, the technique of paper chromatography has been used to follow the progress of amino acid release from tissue exposed to several plant and animal proteases.

EXPERIMENTAL PROCEDURE

Human Aorta Tissue.—The aorta was selected as a tissue subject to the earliest and most extensive atherosclerosis (3). Human aortae obtained from postmortem examinations were immediately refrigerated and experiments started within 24 hours. None of the individuals had died as a result of heart or circulatory ailment. A 3-inch section of the upper aorta immediately below the three branches at the aortic arch, which is subject to minimal atherosclerosis, was compared with the aorta between the celiac artery junction and the pelvic bifurcation, where sclerotic lesions generally are maximal in their severity. The tissue was stripped free of adventitia and was washed free of soluble nitrogen and salts by repeated soakings in distilled water over approximately a 2 hour period. At the end of this time the final change of water tested negative for chloride ion.

The tissue was blotted on filter paper, weighed, and dried overnight on a glass rack

Submitted for publication October 8, 1953.

[1] On leave from the Pineapple Research Institute of Hawaii, Honolulu, T. H.

placed in a vacuum desiccator over concentrated sulfuric acid. After the dry weight was obtained, the tissue was ground to 20-mesh particles in a small Wiley mill and stored at 2 C. until used.

Cross-Linked Hog Aorta Tissue.—Hog aorta intimal tissue prepared as above was experimentally cross-linked by placing in either acetaldehyde or benzoquinone solution. The former leads to a hydrothermally unstable cross link, the latter to a stable linkage (2). In initial experiments, 300 mg. tissue were allowed to rehydrate in 2 ml. water, then 2 ml. of a 1.0 per cent solution of the cross-linking agent (or water, for the control) and 2 drops of toluene were added and the mixture let stand 20 hours at room temperature. Excess cross-linking agent was then washed out of the tissue, which was again dried *in vacuo*.

For later experiments, 200 mg. tissue were soaked in 0.1 per cent benzoquinone for 1, 2, or 4 hours, after which it was washed repeatedly and dried. The control tissue was soaked in distilled water for 4 hours.

Enzymes. — Trypsin (1:300)[1], pepsin (1:10,000)[1], papain[1], ficin[1], pineapple bromelain[2], and carboxypeptidase (3X crystallized suspension)[3] were selected as likely to differ widely in the selective hydrolysis of various bonds in the tissue proteins.

Pepsin was prepared as a 10 per cent concentrated stock solution in M/20 pH 5 phosphate buffer and was dialyzed overnight at 2 C. against buffer to remove amino acid impurities which were found to be present. The solution was diluted to 1 per cent immediately prior to use.

Trypsin was prepared as a 1 per cent solution in M/20 pH 3 phosphate buffer, and was also dialyzed overnight in the cold.

Papain was prepared as a 1 per cent solution in M/20 pH 10 phosphate buffer and was dialyzed overnight at 2 C. Immediately prior to use, it was activated by adding 10 drops of 2M KCN per milliliter of enzyme solution and letting the solution stand 5 to 10 minutes.

Ficin, bromelain, and carboxypeptidase were prepared as 1 per cent solutions (of the crystal suspension rather than the solids in the case of carboxypeptidase) in M/20 pH 3 phosphate buffer. There was no amino acid blank in these solutions, hence dialysis was omitted.

The enzyme solutions were prepared fresh every 4 days and kept under refrigeration. Each preparation was tested for free amino compounds and found to be negative.

Hydrolysis.—To 25 mg. dry tissue were added 2.0 ml. solution adjusted to a pH favorable for the particular enzyme. For pepsin, M/100 HCl at pH 2 was used. For ficin, M/20 phosphate buffer at pH 5, and for the other enzymes, M/20 phosphate buffer at pH 7.5 was used.

0.1 ml. of enzyme solution and 2 drops of toluene were added, the tubes were stoppered and placed in a water bath maintained at 37 C. The tubes were swirled occasionally during the run. After 23 hours, the tubes were removed and placed in ice water to stop further action.

Controls consisting of tissue plus M/100 HCl and tissue plus pH 7.5 buffer but without added enzyme were also run and were found consistently negative for free amino compounds.

Acid hydrolysis to obtain the total amino acids in the tissue was effected by heating 25 mg. tissue with 1.0 ml. 6N H_2SO_4 in a sealed ampule at 110 C. for 16 hours. The ampule was then cooled, 3.0 ml. water added, and the sulfuric acid removed by addition of 700 mg. $Ba(OH)_2$. Excess barium ion was removed by making the final solution slightly acid with a drop or two of H_2SO_4.

Paper Chromatography.—7 microliter aliquots of the hydrolysates were spotted onto Whatman No. 1 chromatography paper. Enzyme hydrolysates were tested after 4 hours and 23 hours, and 3 aliquots were superimposed on the paper to give a total of 21 microliters for each spot (representing about 260 micrograms dry tissue). A single

[1] Nutritional Biochemicals Corporation.
[2] A highly purified sample obtained through the courtesy of Dr. Ralph Heinicke, Pineapple Research Institute of Hawaii.
[3] Worthington Biochemicals Sales Company

7 microliter aliquot (representing about 40 micrograms dry tissue) sufficed for the acid hydrolysates.

A reference spot containing known amino acids was added to each of the papers. A satisfactory reference solution which covered the R_f values of the amino acid mixture obtained from the acid and enzyme hydrolysis of aorta tissue consisted of 3.3 micrograms each of glycine, threonine, alanine, tryptophan, valine, and leucine, and 1.6 micrograms each of aspartic acid, cystine, glutamic acid, and asparagine per 21 microliters used.

The papers were prepared in duplicate; one was developed with 4:1 (w/v) phenol-water, the other with 4:1:1 (v/v/v) butanol-acetic acid-water for 12 to 18 hours. This technique offered most of the advantages of two-dimensional paper chromatography when master overlays marked for the locations of the various amino acids in the particular solvent were used (4). At the same time, it enabled the examination of some 28 samples in a single day, using 2 cylindrical chromatography jars, whereas the conventional two-dimensional chromatography would have required two days and 28 such jars.

The air-dried papers were sprayed with 0.25 per cent ninhydrin in water-saturated butanol and examined after standing overnight at room temperature. A rough estimate of the amount of each amino acid found to be present was made from the size and color intensity of the spot as compared to the reference standard.

Results

The experimental data are summarized in tables 1 to 14. Data on the runs using carboxypeptidase are not included since this enzyme consistently failed to release any detectable amount of free amino compounds in 23 hours. Similarly, the data on enzymic hydrolysis after 4 hours are not included since they qualitatively resemble the 23 hour data but at a greater dilution.

The age and sex of the individual and the condition of the aortae are listed in table 1, together with the percentage of solids in the washed aorta tissue. The extent of sclerosis is closely related to the solids content.

The amino acids obtained from acid hydrolysis of both the upper and lower sections of the tissue are listed in table 2, together with a rating of the relative amount of each. Similarly, tables 3 to 7 show the amino acids released by digestion of aorta tissue with trypsin, pepsin, papain, ficin, and pineapple bromelain, respectively.

Fourteen amino acids were readily detected in the acid hydrolysates, in addition to which glutamine and asparagine were found to be present in enzyme hydrolysates of the aorta tissue. The amino acid makeup seemed remarkably similar for tissues of different ages and different degrees of sclerosis, as well as for the sclerosis-susceptible lower aorta and resistant upper aorta sections. A higher solids content, presumably a result of cal-

Table 1. Physical Data on Human Aortae Used for Protein Studies

	Sample Number								
	37	35	27	40	22B	22A	38	29	32
Age	3 days	18 years	23 years	53 years	55 years	55 years	71 years	73 years	76 years
Sex	F	M	M	F	M	M	M	F	F
Sclerosis	None	None	None	Light	Light	Heavy	Light	Heavy	Heavy
% Dry Weight									
Upper	10.4	13.1	16.9	16.2	15.5	15.4	15.5	17.2	23.5
Lower		11.6	14.4	16.7	15.4	35.2	16.7	37.9	47.2

TABLE 2. AMINO ACIDS FOUND UPON ACID HYDROLYSIS OF HUMAN AORTAE[1] OF DIFFERENT AGES

Amino acid	#37 3 days	#35 18 years	#27 23 years	#40 53 years	#22B 55 years	#22A 55 years	#38 71 years	#29 73 years	#32 76 years
Aspartic acid	3	2–2	2–2	3–3	2–3	2–2	2–3	2–2	2–2
Cystine and Cysteine	3	2–2	2–2	2–2	2–2	1–1	2–2	2–2	2–1
Glutamic acid	4	3–3	3–3	3–3	3–3	3–3	3–3	3–3	3–3
Serine	3	2–2	3–3	4–4	4–3	4–3	3–3	3–3	4–3
Glycine	5	4–4	4–4	4–4	4–5	4–4	4–4	4–4	4–3
Threonine	4	3–3	3–3	4–4	4–4	3–3	3–3	4–2	3–2
Lysine		1–1	2–2	1–1	2–2	2–2	2–2	2–2	2–2
Tyrosine	3	2–2	3–3	3–3	3–3	3–2	3–3	2–1	2–1
Alanine	4	5–4	4–4	4–4	4–4	4–3	4–4	4–3	4–3
Hydroxyproline	4	4–4	4–4	4–4	4–4	4–3	3–4	4–3	3–2
Valine	4	4–3	4–4	4–4	4–4	4–3	4–3	3–2	3–2
Leucines	5	4–4	4–4	4–4	4–4	4–3	4–4	4–3	3–2
Phenyl alanine	3	1–1	1–1	2–2	2–0	1–1	2–2	1–0	1–1
Proline	4	4–4	4–4	3–3	4–4	4–3	3–4	4–3	3–2

[1] First number = upper aorta, second = lower aorta. Numbers rate area and intensity of spot on chromatogram; 1 = trace, 4 = approximating 3 microgram spot from standard solution.

TABLE 3. AMINO ACIDS RELEASED FROM HUMAN AORTAE[1] OF DIFFERENT AGES BY DIGESTION WITH TRYPSIN FOR 23 HOURS AT 37 C.

Amino acid	#37 3 days	#35 18 years	#27 23 years	#40 53 years	#22B 55 years	#22A 55 years	#38 71 years	#29 73 years	#32 76 years
Aspartic acid	2	2–2		2–2	0–2	0–2	2–2	2–1	
Cystine and Cysteine	2	2–2	2–2	2–2	2–2	3–2	3–2	2–1	2–2
Glutamic acid	2	2–2	2–1	2–2	2–2	2–2	2–3	2–2	2–0
Serine	2	3–2	2–2	3–3	2–2	2–2	4–3	2–1	
Glycine	2	2–1		2–2	0–2	2–2	2–2	2–2	2–1
Threonine	2	3–3	2–2	3–3	0–2	3–2	3–3	2–0	2–0
Tyrosine	2	3–2	0–1	2–1	2–3	1–1	1–2		
Glutamine and Asparagine	3	2–2	2–2	3–3	2–2	2–2	3–3	2–2	3–3
Alanine	3	3–4	3–3	3–3	3–3	3–3	3–4	3–3	3–2
Valine	4	4–4		4–4		3–2	3–3	2–2	2–1
Leucines	4	4–4	3–3	3–4	3–3	4–4	4–4	3–3	2–2
Phenyl alanine	2	2–2			2–0		2–1		

[1] First number = upper aorta, second = lower aorta. Numbers rate area and intensity of spot on chromatogram; 1 = trace, 4 = approximating 3 microgram spot from standard solution.

cium deposition, resulted in less protein in the sample taken and hence, in a dilution of the amino acids released from the older tissues, particularly the 3 which had heavily calcified plaques.

The greatest amount of free amino acids from enzyme action on the aorta tissue was obtained using ficin (table 6), bromelain (table 7), or trypsin (table 3). Ficin (and to a lesser extent, papain) also released quantities of peptides which reacted with ninhydrin and made difficult the identification of cer-

tain of the amino acids. Papain proved rather ineffective on the tissue even though activated with cyanide prior to use (table 5). As expected, pepsin released the fewest amino acids and in the least quantity (table 4). As with the acid hydrolysates, the amount and nature of the amino acids released by each of the enzymes were very similar for tissues of different ages or for the different parts of the aorta. This is despite the fact that the several enzymes are attacking different linkages in the proteins with different degrees of effectiveness. For example, ficin seemed to release less serine than did bromelain or trypsin, trypsin seemed to release less glycine than did bromelain or ficin, yet all 3 of these enzymes released similar amounts of leucine and isoleucine.

Other evidence for the action of these enzymes on different linkages is afforded by the degree of solubilization of the aorta tissue by the proteases as compared with buffer controls (table 8). The extensive proteolysis shown by pepsin and papain was restricted largely to release of polypeptides, whereas trypsin and pineapple bromelain released free amino acids rather than large amounts of polypeptides. Ficin was most effective in at-

TABLE 4. AMINO ACIDS RELEASED FROM HUMAN AORTAE[1] OF DIFFERENT AGES BY DIGESTION WITH PEPSIN FOR 23 HOURS AT 37 C.

Amino acid	#37 3 days	#35 18 years	#27 23 years	#40 53 years	#22B 55 years	#22A 55 years	#38 71 years	#29 73 years	#32 76 years
Glutamic acid		1–1		2–2	0–2		2–2	1–1	2–1
Threonine		0–1	0–1	2–0			2–2	1–0	
Glutamine and Asparagine	2			1–2			2–2	1–2	1–1
Alanine	2	2–2	1–1	2–2	1–2	2–1	2–2	2–0	
Valine	1	1–0					2–1		
Leucines	1	2–2	1–2	2–2	1–2	2–1	3–2	2–1	2 0
Phenyl alanine	2	1–1					2–0		

[1] First number = upper aorta, second = lower aorta. Numbers rate area and intensity of spot on chromatogram; 1 = trace, 4 = approximating 3 microgram spot from standard solution.

TABLE 5. AMINO ACIDS RELEASED FROM HUMAN AORTAE[1] OF DIFFERENT AGES BY DIGESTION WITH PAPAIN FOR 23 HOURS AT 37 C.

Amino acid	#37 3 days	#35 18 years	#27 23 years	#40 53 years	#22B 55 years	#22A 55 years	#38 71 years	#29 73 years	#32 76 years
Cystine and Cysteine	2	1–2		2–2		1–0	2–2	1–0	2–2
Glycine		1–0	2–1	2–1		1–0	2–0	1–0	
Threonine				1–1					
Tyrosine		2–2	0–2	2–2	0–2	1–0	2–1	1–0	
Glutamine and Asparagine	2	2–1	1–1	3–3		0–1	2–2	1–0	1–2
Alanine	2	2–1	0–2	3–3	1–2	2–1	3–2	2–1	1–0
Valine	2	3–2	1–0	1–1		3–1	2–1		
Leucines	1	3–3	3–3	4–4	3–2	4–1	3–1	3–1	2–1
Proline			1–1				1–0	1–0	

[1] First number = upper aorta, second = lower aorta. Numbers rate area and intensity of spot on chromatogram; 1 = trace, 4 = approximating 3 microgram spot from standard solution.

TABLE 6. AMINO ACIDS RELEASED FROM HUMAN AORTAE[1] OF DIFFERENT AGES BY DIGESTION WITH FICIN FOR 23 HOURS AT 37 C.

Amino acid	#37 3 days	#35 18 years	#27 23 years	#40 53 years	#22B 55 years	#22A 55 years	#38 71 years	#29 73 years	#32 76 years
Aspartic acid	1	2–2		2–2	0–2		1–1	1–1	
Cystine and Cysteine	2	2–2	2–2	2–2	2–2	2–2	2–2	2–2	2–2
Glutamic acid	3	2–3		2–2	0–2	2–0	2–2	1–2	2–1
Serine		2–2	2–2	2–1	1–0	2–0	1–2		
Glycine	3	3–3	2–2	4–3	2–2	3–2	4–3	3–2	2–2
Threonine	1	2–2	2–2	2–2		2–2	1–2		1–0
Tyrosine		3–3		0–2	1–1	2–0	0–3	0–1	
Glutamine and Asparagine	3	2–2	3–2	3–3	3–2	3–2	3–4	2–2	3–3
Alanine	4	4–4	4–4	4–3	4–3	4–4	4–4	3–3	3–3
Valine	4	4–4	2–0	3–3	2–2	2–3	4–3	3–2	2–3
Leucines	4	4–4	3–3	4–4	4–4	4–4	4–4	4–2	3–3

[1] First number = upper aorta, second = lower aorta. Numbers rate area and intensity of spot on chromatogram; 1 = trace, 4 = approximating 3 microgram spot from standard solution

TABLE 7. AMINO ACIDS RELEASED FROM HUMAN AORTAE[1] OF DIFFERENT AGES BY DIGESTION WITH PINEAPPLE BROMELAIN FOR 23 HOURS AT 37 C.

Amino acid	#37 3 days	#35 18 years	#27 23 years	#40 53 years	#22B 55 years	#22A 55 years	#38 71 years	#29 73 years	#32 76 years
Aspartic acid	2	2–2		2–3	2–2		2–2	2–2	0–1
Cystine and Cysteine	2	2–2	2–2	2–2	2–2	2–2	2–2	2–2	2–2
Glutamic acid	2	2–2	1–1	3–2	0–2	2–2	3–3	2–2	2–1
Serine	2	3–2	1–2	2–2	2–2	2–0	4–3	1–1	1–1
Glycine	2	3–2	2–2	4–4	2–2	3–3	4–4	3–3	3–3
Threonine	3	3–2	2–2	2–2		2–1	3–2		
Tyrosine	2	2–2		2–2	1–2	1–1	0–3		
Glutamine and Asparagine	3	2–2	2–2	3–2	0–2	3–3	3–3	2–2	3–3
Alanine	3	3–3	3–2	4–4	4–4	3–3	4–4	3–3	3–3
Valine	2	4–4		4–4	3–1	4–4	4–4	4–3	3–2
Leucines	4	4–4	3–3	4–4	3–4	4–4	4–4	4–4	3–3
Phenyl alanine				1–1			2–1		

[1] First number = upper aorta, second = lower aorta. Numbers rate area and intensity of spot on chromatogram; 1 = trace, 4 = approximating 3 microgram spot from standard solution.

tacking the tissue because it split off considerable quantities of both peptides and free amino acids.

That certain cross-linkages could be demonstrated by the technique of enzyme digestion is shown in tables 9 to 14, using hog aorta tissue. Cross-linking with either acetaldehyde or benzoquinone had no effect on the amino acids released from the protein by acid hydrolysis (table 9). Acetaldehyde treatment did not alter the amino acid pattern from enzyme digestion of the tissue (tables 10 to 14), probably because of reversion of the hydrothermally unstable linkage

TABLE 8. PERCENTAGE OF AORTA TISSUE SOLUBILIZED BY DIGESTION WITH VARIOUS PROTEOLYTIC ENZYMES FOR 23 HOURS AT 37 C.

Enzyme	Lower aorta	Upper aorta	Average Human aorta	Hog aorta
Trypsin	34.9	30.9	32.9	26.0
Pepsin	40.3	42.5	41.4	
Papain	48.0	41.2	44.6	
Ficin	62.5	61.9	62.2	59.0
Bromelain	30.3	23.2	26.8	18.8

TABLE 9. AMINO ACIDS[1] RELEASED BY ACID HYDROLYSIS FROM HOG AORTA TISSUE CROSS-LINKED WITH ACETALDEHYDE AND BENZOQUINONE FOR VARYING PERIODS OF TIME.

	Hog Aorta #25H, 20 Hr. Treatment			Hog Aorta #25L, 0.1% Quinone Treatment			
Amino acid	Untreated Control	0.5% Acetaldehyde	0.5% Quinone	Untreated Control	1 Hr.	2 Hr.	4 Hr.
Aspartic acid	2	2	2	2	2	2	2
Cystine and Cysteine	2	2	2	2	2	2	2
Glutamic acid	3	3	3	3	3	3	3
Serine		2	2	3	3	2	3
Glycine	4	4	4	4	4	4	4
Threonine	3	2	3	3	3	3	3
Lysine				1		1	1
Tyrosine	2	2	2	2	2	2	2
Alanine	4	4	4	4	4	4	4
Valine	4	4	4	4	4	4	4
Leucines	4	4	4	4	4	4	4
Phenyl alanine	2	2	2	2	2	2	2

[1] Numbers rate area and intensity of spot on chromatogram; 1 = trace, 4 = approximating 3 microgram spot from standard solution.

during washing and drying; thus, such unstable links would not be determined by the enzyme procedure. Benzoquinone, however, effected a very marked reduction in susceptibility of the tissue to proteolysis by the various enzymes.

The cross-linking had a fairly general inhibitory effect on peptide bond splitting and did not act by reducing the appearance of only a few amino acids. However, the release of some, notably the sulfur-containing amino acids, was not reduced by a 4 hour treatment with 0.1 per cent quinone, and even after almost all proteolysis of the tissue had been repressed by treating with 0.5 per cent quinone for 20 hours certain of the enzymes were able to release these amino acids. Inhibition of proteolysis was not caused by the presence of excess cross-linking agent which could poison the enzyme in the buffer solution, since a mixture of untreated tissue with tissue cross-linked with quinone gave an amino acid picture with ficin similar to that of the control tissue alone (table 13).

DISCUSSION

The present study, using the entire water-insoluble proteins of the aorta, fails to confirm the findings of Lansing and associates (5, 6) on medial elastin. No increase in

TABLE 10. AMINO ACIDS[1] RELEASED BY DIGESTION WITH TRYPSIN FOR 23 HOURS AT 37 C. FROM HOG AORTA TISSUE CROSS-LINKED WITH ACETALDEHYDE AND BENZOQUINONE FOR VARYING PERIODS OF TIME.

	Hog Aorta #25H, 20 Hr. Treatment			Hog Aorta #25L, 0.1% Quinone Treatment			
Amino acid	Untreated Control	0.5% Acetaldehyde	0.5% Quinone	Untreated Control	1 Hr.	2 Hr.	4 Hr.
Aspartic acid				2		1	
Cystine and Cysteine	2	2	2	2	2	2	2
Glutamic acid	1	1		2	1	1	
Serine				1			
Threonine				2		1	1
Tyrosine						2	
Glutamine and Asparagine	3	3		2	2	2	2
Alanine	3	2		3	2	2	3
Valine	2			1		2	
Leucines	3	3	1	2	1	2	2
Phenyl alanine				1			

[1] Numbers rate area and intensity of spot on chromatogram; 1 = trace, 4 = approximating 3 microgram spot from standard solution.

TABLE 11. AMINO ACIDS[1] RELEASED BY DIGESTION WITH PEPSIN FOR 23 HOURS AT 37 C. FROM HOG AORTA TISSUE CROSS-LINKED WITH ACETALDEHYDE AND BENZOQUINONE FOR VARYING PERIODS OF TIME.

	Hog Aorta #25H, 20 Hr. Treatment			Hog Aorta #25L, 0.1% Quinone Treatment		
Amino acid	Untreated Control	0.5% Acetaldehyde	0.5% Quinone	1 Hr.[2]	2 Hr.	4 Hr.
Threonine	1	1				
Glutamine and Asparagine	1	1		2	1	2
Alanine	2	1		1	1	2
Valine	2	1				
Leucines	2	1		1	1	1

[1] Numbers rate area and intensity of spot on chromatogram; 1 = trace, 4 = approximating 3 microgram spot from standard solution.
[2] No untreated control run for this enzyme owing to shortage of tissue.

dicarboxylic amino acids with age was observed, nor did the lower aorta seem to differ from the upper aorta in the amino acid make-up of the tissue proteins. Presumably the inclusion of the intimal proteins as well as the considerable amount of medial collagen in the present study masked the small changes in composition which might have occurred in the medial elastin studied by Lansing. These changes may be associated with aging of the one protein component, but are not universally associated with aging of the wall of the aorta. Lansing and associates (6) already had shown that these changes were not typical of aging for all arterial tissues.

No hydrothermally stable cross-linkage that could be associated with age or with a particular section of the aorta was observed by the technique of comparing susceptibility to various proteases. If such links were extensive and similar in protease resistance to

TABLE 12. AMINO ACIDS[1] RELEASED BY DIGESTION WITH PAPAIN FOR 23 HOURS AT 37 C. FROM HOG AORTA TISSUE CROSS-LINKED WITH ACETALDEHYDE AND BENZOQUINONE FOR VARYING PERIODS OF TIME.

	Hog Aorta #25H, 20 Hr. Treatment			Hog Aorta #25L, 0.1% Quinone Treatment			
Amino acid	Untreated Control	0.5% Acetaldehyde	0.5% Quinone	Untreated Control	1 Hr.	2 Hr.	4 Hr.
Cystine and Cysteine	2	1		1	1	1	1
Tyrosine				1		1	1
Glutamine and Asparagine	2	2		2	2	2	2
Alanine	2	1		3	1	1	1
Valine	2	2		2			
Leucines	3	2		3	1	1	1
Phenyl alanine	1	1					

[1] Numbers rate area and intensity of spot on chromatogram; 1 = trace, 4 = approximating 3 microgram spot from standard solution.

TABLE 13. AMINO ACIDS[1] RELEASED BY DIGESTION WITH FICIN FOR 23 HOURS AT 37 C. FROM HOG AORTA TISSUE CROSS-LINKED WITH ACETALDEHYDE AND BENZOQUINONE FOR VARYING PERIODS OF TIME.

	Hog Aorta #25H, 20 Hr. Treatment				Hog Aorta #25L, 0.1% Quinone Treatment			
Amino acid	Untreated Control (a)	0.5% Acetaldehyde	0.5% Quinone (b)	(a) & (b) Mixed	Untreated Control	1 Hr.	2 Hr.	4 Hr.
Aspartic acid	1	1		1	1	1	1	1
Cystine and Cysteine	2	2	1	2	2	2	2	2
Glutamic acid	2	1		2	2	1	1	1
Threonine		1			1		1	
Glutamine and Asparagine	3	3	1	3	3	2	2	2
Alanine	3	3	1	3	4	3	3	3
Valine	3	3		2	3	2	2	2
Leucines	3	3	1	2	4	2	2	2
Phenyl alanine	2	2		2	2			

[1] Numbers rate area and intensity of spot on chromatogram; 1 = trace, 4 = approximating 3 microgram spot from standard solution

the experimentally cross-linked tissue prepared using benzoquinone, their presence would have been detected. However, less extensive cross-linking might have remained unnoticed because of the incompleteness of proteolysis. For example, as would be expected for albuminoids, 1/3 to 2/3 of the tissue was not even solubilized, and a substantial portion of the soluble nitrogen remained as peptides after 23 hours. Both of these fractions resistant to proteolysis conceivably might have possessed undetected stable cross-links.

The marked reduction in proteolysis observed for certain of the experimentally cross-linked aorta tissues parallels observations of others using different cross-linking agents. Sizer (9) notes that resistance of collagen

TABLE 14. AMINO ACIDS[1] RELEASED BY DIGESTION WITH PINEAPPLE BROMELAIN FOR 23 HOURS AT 37 C. FROM HOG AORTA TISSUE CROSS-LINKED WITH ACETALDEHYDE AND BENZOQUINONE FOR VARYING PERIODS OF TIME.

	Hog Aorta #25H, 20 Hr. Treatment			Hog Aorta #25L, 0.1% Quinone Treatment			
Amino acid	Untreated Control	0.5% Acetaldehyde	0.5% Quinone	Untreated Control	1 Hr.	2 Hr.	4 Hr.
Aspartic Acid				1			
Cystine and Cysteine	2	2		2	2	2	2
Glutamic acid				2			
Threonine				1			
Tyrosine				1			
Glutamine and Asparagine	2	2		2	1	1	
Alanine	2	2		2		1	1
Valine	2						
Leucines	2	2		2			

[1] Numbers rate area and intensity of spot on chromatogram; 1 = trace, 4 = approximating 3 microgram spot from standard solution

sutures to enzyme action is increased by chrome tanning and that the reduced proteolysis is proportional to the amount of chrome in the suture. For example, a 300-fold increase in the time required for tryptic digestion resulted when the chrome content increased from 0 to 5 per cent. Sizer (9) states that "other types of tanning agents have a similar effect in increasing the resistance of collagen to the action of trypsin," but notes that chemical combination of formaldehyde with collagen did not interfere with tryptic hydrolysis. This is in line with the observations reported here that acetaldehyde treatment was ineffective in reducing proteolysis. However, neither pepsin, trypsin, ficin, papain, nor pineapple bromelain was capable of splitting stable protein cross-links such as resulted from exposure to benzoquinone.

Previous work on the effect of proteolytic enzymes on proteins such as are found in the arterial wall has emphasized solubilization rather than appearance of free amino acids. Sizer (8, 9) studied the solubilization of tendon collagen by trypsin, pepsin, and other proteases, and found pepsin but not the others to be effective. However, when the fibrils were reduced to small particles, the other proteases became effective, a finding in agreement with the present study on aorta proteins. Dry heat (130 C.) increased the resistance to trypsin and pepsin, which Sizer ascribed to lesser swelling as well as to more firm cross-linking. Neuman and Tytell (7) reported somewhat different findings in that while pepsin acted readily, neither papain nor trypsin was effective even on blendorized collagen, and stated that resistance of the native collagen to tryptic digestion could be eliminated by heat denaturation (60 to 70 C. in solution). However, these studies on tendon collagen are not necessarily applicable to all collagen sources; Banga and associates (1) have reported that collagen from the human aorta has different physical properties than that from the Achilles tendon prepared in the same way.

SUMMARY

Paper chromatographic analysis has been used to study the effect of age on amino acids in human aorta tissue, as well as to follow the progress of amino acid release from tissue in the presence of the proteolytic enzymes, trypsin, pepsin, papain, ficin, pineapple bromelain, and carboxypeptidase.

Aspartic acid, glutamic acid, asparagine, glutamine, cysteine and cystine, serine, glycine, threonine, lysine, tyrosine, alanine, proline, hydroxyproline, valine, leucine and isoleucine, and phenyl alanine were readily detected in the aorta. No shift in the gross amino acid makeup of either the upper or lower aorta was noted as a function of age.

The rate of release of amino compounds as well as the qualitative and quantitative composition of the amino acids obtained as the result of protease action did not change with increasing age of the tissue or with increasing sclerosis of the aorta. Similarly, the sclerosis-resistant upper aorta near the aortic arch reacted essentially identically with the more susceptible lower aorta near the pelvic bifurcation.

Considerable differences existed in the digestive effects of the several proteases on aorta tissue. Ficin> papain> pepsin> trypsin> bromelain was the order in solubilizing the tissue, whereas in release of free amino acids the order was ficin> bromelain> trypsin> papain> pepsin. Bromelain was the most efficient in converting the solubilized protein to amino acids, followed by trypsin and ficin.

Extensive cross-linking of hog aorta proteins with benzoquinone markedly reduced susceptibility of the tissue to proteolysis by all of the enzymes studied. Treatment with acetaldehyde as a more hydrothermally-unstable cross-linking agent had little or no effect on subsequent enzyme action.

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THE EFFECTS OF STILBESTROL ON THE RETENTION OF NITROGEN, CALCIUM, PHOSPHORUS, AND POTASSIUM IN AGED MALES WITH AND WITHOUT OSTEOPOROSIS

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PREVIOUS studies from this laboratory have demonstrated the ability of aged males to retain significant quantities of nitrogen, phosphorus, and potassium when high protein diets were administered (4). In view of the anabolic characteristics of the estrogenic hormones, it is of interest to find out whether these hormones can further increase nitrogen, phosphorus, and potassium retention when administered to aged males who are already storing these substances under the stimulus of a high protein diet. This constitutes one aim of the present investigation.

Although most of the subjects in the previous investigation were able to retain calcium under the experimental conditions described, the 2 subjects with x-ray evidence of osteoporosis showed only slight retention of calcium even at high levels of intake although they were retaining appreciable amounts of nitrogen, phosphorus, and potassium (4). It was suggested that the failure to store calcium in the face of what seemed to be a high degree of anabolic activity reflected either, (a) a specific defect in the mechanism of building bone matrix, or (b) a defect in the ability to incorporate calcium salts upon the protoplasmic matrix. The role of steroid compounds in senile osteoporosis has been emphasized since Albright, Bloomberg, and Smith (1) reported striking storages of nitrogen and calcium and clinical relief of symptoms following the administration of both androgens and estrogens in individuals with either postmenopausal or senile osteoporosis. It was their thesis, at the time, that the defect in senile osteoporosis was primarily in the inability of the aged individuals to elaborate the protein-rich bone matrix upon which the calcium salts are deposited, and that the steroid hormones, particularly the estrogens, promoted the production of this matrix. The reduction in calcium excretion occurred secondarily as a consequence of the primary effect on protein metabolism.

In view of the previous findings (4), a reexamination of the effects of an estrogenic hormone on nitrogen, phosphorus, potassium, and calcium metabolism in aged males with and without osteoporosis was undertaken in an attempt to distinguish between defects in the laying down of bone matrix and the incorporation of calcium salts in the matrix.

EXPERIMENTAL METHODS

Subjects:—Six ambulatory male patients of the Baltimore City Hospitals were selected on the basis of a detailed history, physical examination, and a series of laboratory studies. With the exception of the x-ray diagnosis of osteoporosis in 3 of the patients (W.Ra., G.S., and A.Ha.), and a high normal serum alkaline phosphatase level in Ra., these subjects were considered to be free of disorders that might have primarily altered calcium, phosphorus, nitrogen, or potassium metabolism. The diagnosis of senile osteoporosis depended upon the demonstration by x-ray[1] of the following:

1) decreased density of bone, 2) widening

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[1] The skeletal evaluation by x-ray included technically satisfactory films of at least the following bones in all subjects: AP and lateral skull, dorsal and lumbar spine, AP pelvis, AP and lateral views of the femur and humerus, PA chest. In some of the subjects, cervical spine, shoulders, forearms, and lower legs were also examined. We are indebted to Dr. John DeCarlo, Roentgenologist in Chief, Baltimore City Hospitals, for these examinations and interpretations.

of the intervertebral spaces with narrowing and concavity of the vertebral bodies, and 3) coarsening of the trabecular markings. The exclusion of other causes of the osteoporosis such as hyperparathyrodism, extensive metastatic malignancy, and myleomatosis was based upon the clinical and laboratory findings.

Laboratory findings and clinical descriptions of 5 of the subjects have been reported previosuly (4). By comparison with the prior study, slightly higher values for serum alkaline phosphatase were now noted. In 1 subject, the increase was 4 Bodansky units. The change in the others was between -2.2 and +2.4 units. Hemoglobin levels were now 13.5 Gm.% or higher, and no pertinent differences in clinical status were disclosed.

The sixth subject was A.Ha., a 75 year old white separated male admitted three months prior to the onset of the balance study. Three previous admissions to this hospital were for acute pulmonary infections secondary to bronchiectasis, and for generalized weakness believed to be related to malnutrition and alcoholism. The current admission was for "inability to walk." This patient had worked as a freight yard employee as a young man, then at numerous active occupations, finally as an installment collector. In recent years he had become dependent upon welfare support. Within the two years prior to admission he noted the onset of generalized weakness with recent progression. When he was unable to feed and care for himself, he was admitted for evaluation and domiciliary care.

His remote history included typhoid fever. During the past three years he noted development of exertional dyspnea, a cough productive of white mucoid sputum accompanied by wheezing, increased during respiratory infections. There was no history of chest pain or hemoptysis but occasional evening ankle edema did occur. All but 3 carious teeth had been removed at about the age of 40. His dentures had not been servicable for about six years. Vision in the left eye was reduced following trauma at the age of 60. His dietary history indicated a limited food intake—usually one meal a day, and quantitatively poor in protein, during the past five to ten years. He denied excessive use of alcohol during this period. On examination he was a small lean pallid kyphotic individual appearing chronically ill. His left eye was aphakic, with corneal scarring, secondary glaucoma, and optic atrophy. Respirations were mainly abdominal, a hyperresonant chest was maintained in a predominantly inspiratory position. The diaphragms were low and with decreased excursion. Diffuse rhonchi and occasional wheezes, but no rales were heard. The prostate was firm and symmetrically slightly enlarged. Neuromuscular examination demonstrated generalized weakness and loss of muscle mass but no specific group seemed more evidently affected. He was unable to stand without assistance. Sensory examination was unremarkable.

Laboratory data showed acid casual urines of maximum specific gravity = 1.018, no proteinura, and occasional to moderate numbers of white cells in the sediment.

His hemoglobin was 14 Gm.% with an hematocrit of 40 and a normal white count. The plasma NPN was 41 mg.%, serum protein 7.4 Gm.%, calcium 9.4, phosphorus 2.6 mg.%, and alkaline phosphatase 5.1 Bodansky units. Sputum cultures for tubercle bacilli were negative. X-ray of the chest showed increased bronchovascular markings, blunting of the costophrenic angles, and radiolucence compatible with pulmonary emphysema. The gastrointestinal tract and an intravenous urogram showed no roentgenological abnormality. Skeletal x-rays revealed no abnormality of the skull; there was a loss of lordotic curvature in the cervical spine with demineralization and joint space narrowing between C5 and C6. Old bilateral healed rib fractures were noted and films of the dorso-lumbar spine showed extreme demineralization of all bones with compression of 7 vertebral bodies. There was evidence of an old fracture of the superior ramus of the right pubic bone and possibly on the left as well, and of only minimal osteoarthritis.

On a regular diet and care, he became semi-ambulatory. His cough and sputum diminished. An epidermophytosis of the feet and ankles was successfully treated one month prior to the start of the balance study. At this time, he felt much improved and was up and about the ward using a cane.

Procedure:—The study was divided into 12 5-day periods during the months of October and November. After 4 control periods, stilbestrol was administered by mouth (2.0 mg. 3 times per day) for 4 periods, followed by 4 control periods. Dietary intakes were constant throughout all 12 periods. The 3 menus shown in table 1 were used, in the following order, for each 5-day period: I, II, III, I, II. Chemical analysis of the diets gave the following intakes per day: nitrogen, 16.8 Gm.; phosphorus, 1322 mg.; potassium, 70 mEq., and calcium, 624 mg. The calculated caloric intake was 2600 calories per day. Any deviations from these intakes, due to refusal of food, were corrected by chemical analysis of the rejected

TABLE 1
DIETS USED

	Breakfast		Lunch		Supper	
		Weight (Gm.)		Weight (Gm.)		Weight (Gm.)
MENU I	Canned sweetened Orange Juice	200	Beef	150	Pork	100
	Rice Krispies	30	Macaroni	30	Rice	30
	Bread (3X)[1]	150	Peas	100	Tomatoes	100
	Margarine (3X)[1]	50	Pears	100	Apricots	100
	Jelly	60				
	Sanka (3X)[1]	3 pkg.				
	Sugar (3X)[1]	30				
	Evaporated Milk	100				
	Processed Cheddar Cheese	30				
MENU II	Pineapple Juice	200	Beef	150	Pork	100
	Cornflakes	30	Macaroni	30	Rice	30
	Bread (3X)[1]	150	Lima Beans	100	Carrots	100
	Margarine (3X)[1]	50	Fruit Cocktail	100	Applesauce	100
	Jelly	60				
	Sanka (3X)[1]	3 pkg.				
	Sugar (3X)[1]	30				
	Evaporated Milk	100				
	Processed Cheddar Cheese	30				
MENU III	Grapefruit Juice	200	Beef	150	Pork	100
	Wheaties	30	Macaroni	30	Rice	30
	Bread (3X)[1]	150	Corn	100	Green Beans	100
	Margarine (3X)[1]	50	Plums	100	Peaches	100
	Jelly	60				
	Sanka (3X)[1]	3 pkg.				
	Sugar (3X)[1]	30				
	Evaporated Milk	100				
	Processed Cheddar Cheese	30				

[1] Foods were initially served at breakfast, but were also served at the other meals. The figures listed indicate the total amount of that food served during the day.

food and are entered in tables 3 and 4. The food intake for subject, A.Ha., was slightly less (1800 cals./day) than for the other 5 subjects.

All food was prepared and served from a kitchen used solely for the experiments and the subjects were under direct supervision at all times.

The methods of preparing samples for analysis and the chemical methods have been described previously (4).

Each patient was weighed each morning (± 100 Gm.) shortly after arising and before breakfast. Fasting blood samples were drawn at the end of periods 1, 3, 5, 6, 8, 9, 11, and 12 for analysis of calcium, phosphorus, total protein, albumin, globulin, potassium, and alkaline phosphatase by methods previously described (4).

RESULTS

The results are summarized in table 2 and are given in detail in tables 3 and 4. The

TABLE 2
MEAN BALANCES
BASED ON AVERAGE OF LAST 3 PERIODS

	Nitrogen Gm./day			Phosphorus mg./day			Calcium mg./day			Potassium mEq./day		
Normal Subjects	Control	Experimental	Recovery	Control	Experimental	Recovery	Control	Experimental	Recovery	Control	Experimental	Recovery
A. A.	2.30	1.63	1.37	73	33	8	3	60	55	7	1	4
T. B.	1.33	.47	.33	−43	−80	−108	−17	43	−48	6	−3	1
A. He.	2.90	1.73	.57	65	38	+34	11	23	12	9	−3	−2
Average	2.18	1.28	.76	32	−3	−22	−1	42	6	7	−2	1
Osteoporotic Subjects												
W. Ra.	3.13	2.70	1.87	178	141	−38	103	149	22	10	1	0
G. S.	3.37	3.20	2.57	152	207	83	29	167	60	13	9	10
A. Ha.	2.20	1.47	0.53	10	4	−59	6	45	0	0	−4	−3
Average	2.90	2.46	1.66	113	117	−5	46	120	27	8	2	2

figures 1 to 6 are plotted according to the method suggested by Reifenstein, Albright, and Wells (6). The intake is plotted down from the zero line of the ordinate. The sum of the urinary and fecal excretion is plotted upward from the intake line. A clear area between the top of the excretion column and the zero line represents a positive balance whereas if the excretion area exceeds the zero line, the balance is negative. Time is indicated in 5-day periods on the abscissa. All data are plotted in amounts per 24 hours. The scales are chosen to represent physiologic equivalents in body tissue (i.e., 3 Gm. N ⊖ 200 mg. P ⊖ 400 mg. Ca and 8 mEq. K).

Since the hormone was given orally, the effects may not be developed during the first period of its administration (Period 5) and its effects in all probability carried over into at least Period 9. Consequently, comparisons were made by computing average balances for each subject in Periods 2, 3, and 4 (control), Periods 6, 7, and 8 (experimental), and Periods 10, 11, and 12 (recovery).

Nitrogen Balance:—During the control periods, all 6 subjects were in marked positive nitrogen balance with a trend toward a reduction in the magnitude of the positive nitrogen balance throughout the experiment (fig. 7A). In all subjects, the nitrogen retention during stilbestrol administration was less than that during the initial control periods. In the 3 non-osteoporotic subjects, there is no indication that stilbestrol induced any positive deviation from the general downward trend. On the other hand, 2 of the osteoporotic subjects give slight evidence that the rate of fall in the positive nitrogen balance was reduced during stilbestrol administration. This difference is so small that it cannot be regarded as clear-cut evidence of a differential effect. The average nitrogen retention was slightly greater for the osteoporo-

TABLE 3. METABOLIC DATA ON SUBJECTS

Subject	Period	Wgt. of Patient (kg.)	Nitrogen (Gm./day)				Phosphorus (mg./day)				Calcium (mg./day)				Potassium (mEq./day)				Serum					
			Intake	Urine	Stool	Balance	Intake	Urine	Stool	Balance	Intake	Urine	Stool	Balance	Intake	Urine	Stool	Balance	Calcium (mg. %)	Phosphorus (mg. %)	Alkaline Phosphatase*	Total Protein (Gm. %)	Albumin (Gm. %)	Globulin (Gm. %)	Potassium (mEq./L.)
A. A. 77 yrs.	1	58.1	16.9	11.5	1.7	+3.7	1322	723	397	+202	627	61	575	- 9	70	44	13	+13	9.8	2.8	3.6	7.1	4.6	2.5	4.5
	2	58.6	16.9	12.4	2.4	+2.1	1322	777	477	+ 68	627	58	590	- 21	70	45	16	+ 9	-	-	-	-	-	-	-
	3	59.0	16.9	12.5	1.8	+2.6	1322	786	384	+152	627	48	476	+103	70	49	11	+10	9.8	2.6	4.2	7.2	4.5	2.7	4.9
	4	59.4	16.9	12.4	2.3	+2.2	1322	789	535	- 2	627	36	663	- 72	70	49	18	+ 3	-	-	-	-	-	-	-
Stilbestrol (6 mg. /day)	5	59.8	16.9	13.2	1.9	+1.8	1322	762	452	+108	627	39	548	+ 40	70	53	14	+ 3	10.0	3.0	3.6	6.5	4.2	2.3	4.7
	6	60.0	16.9	12.9	1.8	+2.2	1322	795	419	+108	627	13	462	+152	70	55	14	+ 1	9.0	3.1	3.4	6.5	4.1	2.4	5.0
	7	60.6	16.9	13.7	1.9	+1.3	1322	823	491	+ 8	627	24	581	+ 22	70	54	15	+ 1	-	-	-	-	-	-	-
	8	60.8	16.9	13.0	2.5	+1.4	1322	752	588	- 18	627	15	607	+ 5	70	50	19	+ 1	9.4	2.7	2.8	6.7	4.2	2.5	4.8
	9	60.8	16.9	13.9	2.4	+0.6	1322	954	509	-141	627	22	560	+ 45	70	55	18	- 3	9.7	2.5	3.1	6.8	4.2	2.6	4.9
	10	60.3	16.9	13.8	1.9	+1.2	1322	906	418	- 2	627	31	487	+109	70	52	15	+ 3	-	-	-	-	-	-	-
	11	60.4	16.9	13.5	2.3	+1.1	1322	882	503	- 63	627	42	589	- 4	70	52	16	+ 2	9.3	2.8	3.5	7.0	4.4	2.6	4.7
	12	60.6	16.9	13.2	1.9	+1.8	1322	797	436	+ 89	627	51	516	+ 60	70	50	14	+ 6	-	-	-	-	-	-	-
T. B. 73 yrs.	1	86.6	16.8	13.3	1.8	+1.7	1323	1021	471	-169	624	145	833	-354	71	59	10	+ 2	9.1	2.9	7.5	7.5	4.3	3.2	4.3
	2	86.6	16.8	14.0	1.4	+1.4	1323	1004	286	+ 33	624	169	373	+ 82	71	56	7	+ 8	-	-	-	-	-	-	-
	3	86.3	16.8	14.1	1.8	+0.9	1323	995	456	-128	624	176	606	-158	71	56	10	+ 5	9.8	2.9	6.8	7.8	4.7	3.1	4.5
	4	86.2	16.8	13.8	1.3	+1.7	1323	1021	336	- 34	624	160	438	+ 26	71	59	8	+ 4	-	-	-	-	-	-	-
Stilbestrol (6 mg. /day)	5	86.3	16.8	14.4	1.6	+0.8	1323	896	437	- 10	624	130	529	- 35	71	62	10	- 1	9.7	2.9	6.4	6.9	4.3	2.6	4.5
	6	86.0	16.8	14.4	1.9	+0.5	1323	972	510	-159	624	98	556	- 30	71	66	12	- 7	9.4	3.1	6.2	7.1	4.3	2.6	5.0
	7	86.1	16.8	14.4	1.5	+0.9	1323	996	386	- 59	624	94	464	+ 66	71	62	9	0	-	-	-	-	-	-	-
	8	86.0	16.8	15.1	1.7	0.0	1323	971	375	- 23	624	93	438	+ 93	71	62	10	- 1	10.3	2.6	4.8	7.4	4.3	3.1	4.8
	9	85.3	16.8	15.8	1.5	-0.5	1323	1013	464	-154	624	109	511	+ 4	71	64	11	- 4	10.4	2.7	4.8	7.3	4.4	2.9	4.8
	10	84.5	16.8	15.7	1.7	-0.6	1323	1082	463	-222	624	128	555	- 59	71	62	10	- 1	-	-	-	-	-	-	-
	11	84.8	16.8	15.2	1.6	0.0	1323	991	420	- 88	624	199	497	- 72	71	61	9	+ 1	10.1	2.5	5.4	7.2	4.3	2.9	4.4
	12	84.6	16.8	13.8	1.4	+1.6	1323	939	397	- 13	624	166	472	- 14	71	60	8	+ 3	-	-	-	-	-	-	-
A. He. 73 yrs.	1	76.5	16.8	11.9	1.2	+3.7	1323	1174	338	-189	624	123	554	- 53	71	48	13	+10	10.0	2.6	5.7	7.5	4.4	3.1	5.1
	2	77.0	16.8	12.5	1.4	+2.9	1323	830	398	+ 95	624	151	513	- 40	71	50	17	+ 4	-	-	-	-	-	-	-
	3	77.3	16.8	13.2	0.6	+3.0	1323	857	405	+ 61	624	156	537	+ 31	71	51	11	+ 9	10.1	2.6	6.7	7.6	4.4	3.2	4.7
	4	77.9	16.8	13.4	0.6	+2.8	1323	879	405	+ 39	624	146	537	+ 41	71	45	11	+15	-	-	-	-	-	-	-
Stilbestrol (6 mg. /day)	5	78.6	16.8	13.4	1.1	+2.3	1323	752	477	+ 94	624	117	548	- 41	71	51	19	+ 1	9.5	2.7	7.6	7.4	4.5	2.9	4.7
	6	79.1	16.8	13.3	1.2	+2.3	1323	754	538	+ 31	624	99	547	- 22	71	49	26	- 4	9.0	2.5	4.5	7.1	3.9	3.2	4.7
	7	78.8	16.8	13.8	1.7	+1.3	1323	819	522	- 18	624	106	533	- 15	71	50	28	- 7	-	-	-	-	-	-	-
	8	78.7	16.8	14.0	1.2	+1.6	1323	750	473	+100	624	79	439	+106	71	44	26	+ 1	9.0	2.2	4.6	7.2	3.8	3.4	4.3
	9	78.6	16.8	15.1	1.0	+0.7	1323	880	471	- 28	624	99	460	+ 65	71	47	15	+ 9	10.7	2.5	4.8	7.3	4.1	3.2	4.5
	10	77.6	16.8	15.3	1.1	+0.4	1323	821	462	+ 40	624	115	454	+ 55	71	53	24	- 6	-	-	-	-	-	-	-
	11	77.7	16.8	15.7	1.0	+0.1	1323	802	477	+ 44	624	129	491	+ 4	71	53	18	0	9.4	2.4	5.6	7.5	4.1	3.4	4.7
	12	77.6	16.8	14.6	1.0	+1.2	1323	829	477	+ 17	624	157	491	- 24	71	53	18	0	-	-	-	-	-	-	-

All periods 5 days in length. *Bodansky Units.

TABLE 4. METABOLIC DATA ON SUBJECTS

TABLE 4. METABOLIC DATA ON SUBJECTS

Subject	Period	Wgt. of Patient (kg.)	Nitrogen (Gm./day)				Phosphorus (mg./day)				Calcium (mg./day)			Potassium (mEq./day)			Serum					
			Intake	Urine	Stool	Balance	Intake	Urine	Stool	Balance	Intake	Urine	Stool	Intake	Urine	Stool	Calcium (mg. %)	Phosphorus (mg. %)	Alkaline Phosphatase*	Total Protein (Gm. %)	Albumin (Gm. %)	Globulin (Gm. %)	Potassium (mEq./L.)
W.Ra. 82 yrs.	1	85.4	16.8	10.2	2.8	+3.8	1323	633	640	+ 50	624	61	654	71	46	22	8.8	2.8	8.9	6.6	4.1	2.5	4.4
	2	86.3	16.8	11.5	2.5	+2.8	1323	543	544	+236	624	76	430	71	41	18	-	-	-	-	-	-	-
	3	87.0	16.8	11.5	1.7	+3.6	1323	591	520	+212	624	64	470	+ 90	71	42	12	+17	10.6	7.0	4.2	2.8	4.3
	4	87.4	16.8	11.0	2.8	+3.0	1323	639	598	+ 86	624	61	463	+100	71	50	20	+ 1	-	-	-	-	-
	5	87.2	16.8	11.4	4.8	+0.6	1323	528	661	+134	624	65	441	+118	71	49	34	-12	10.0	6.6	4.4	2.2	4.3
Stilbestrol	6	88.0	16.8	11.5	2.6	+2.7	1323	555	680	+ 88	624	49	472	+103	71	54	21	- 4	8.7	6.4	4.0	2.4	4.7
(5 mg./day)	7	89.2	16.5	11.5	2.2	+2.8	1299	584	581	+134	619	52	407	+160	70	50	16	+ 4	-	-	-	-	-
	8	90.3	16.8	10.7	3.5	+2.6	1323	508	613	+202	624	41	400	+183	71	45	23	+ 3	8.3	2.4	7.4	6.9	3.6	3.3	4.7
	9	89.4	16.8	11.8	2.5	+2.5	1323	623	608	+ 92	624	47	463	+114	71	48	18	+ 5	9.7	2.3	5.6	6.6	3.7	2.9	4.6
	10	88.6	16.8	12.2	3.0	+1.6	1323	619	716	- 12	624	57	552	+ 15	71	51	21	- 1	-	-	-	-	-	-	-
	11	88.4	16.8	12.4	3.2	+1.2	1323	625	778	- 80	624	65	622	- 63	71	51	22	- 2	8.8	2.6	7.2	6.4	3.9	2.5	4.4
	12	88.2	16.8	11.8	2.2	+2.8	1323	600	744	- 21	624	73	436	+115	71	52	14	+ 5	-	-	-	-	-	-	-
G.S. 70 yrs.	1	59.3	16.8	10.9	1.5	+4.4	1323	656	467	+200	624	125	541	- 42	71	38	16	+17	9.4	2.6	5.1	7.3	4.7	2.6	4.2
	2	59.4	16.8	11.1	1.8	+3.9	1323	675	444	+204	624	145	451	+ 28	71	38	17	+16	-	-	-	-	-	-	-
	3	59.4	16.8	12.0	1.4	+3.4	1323	775	407	+141	624	151	419	+ 54	71	42	16	+13	10.1	2.6	6.4	7.3	4.5	2.8	4.1
	4	59.6	16.7	12.5	1.4	+2.8	1316	798	407	+111	617	193	419	+ 5	70	43	16	+11	-	-	-	-	-	-	-
	5	60.2	16.8	11.6	1.8	+3.4	1323	607	463	+253	624	155	406	+ 63	71	40	18	+13	10.2	2.6	5.7	6.7	4.1	3.2	4.2
Stilbestrol	6	60.3	16.8	10.7	1.8	+4.3	1323	607	467	+249	624	137	349	+138	71	44	18	+ 9	9.8	2.6	4.7	6.7	4.1	2.6	4.4
(6 mg./day)	7	60.0	15.0	10.8	1.5	+2.7	1220	616	428	+176	613	117	323	+173	67	44	14	+ 9	-	-	-	-	-	-	-
	8	59.9	16.4	12.2	1.6	+2.6	1272	662	415	+195	595	121	284	+190	69	45	16	+ 8	8.9	2.2	5.0	6.8	3.9	2.9	4.3
	9	59.7	16.8	12.5	2.1	+2.2	1323	700	541	+ 82	624	139	410	+ 75	71	44	19	+ 8	10.3	2.3	4.7	7.0	4.2	2.8	4.4
	10	59.4	16.8	13.1	1.7	+2.0	1323	864	469	- 10	623	191	375	+ 57	71	48	17	+ 6	-	-	-	-	-	-	-
	11	59.7	16.8	12.7	1.4	+2.7	1323	795	394	+134	624	201	354	+ 69	71	45	14	+12	9.2	2.2	6.2	7.2	4.4	2.8	4.4
	12	60.0	16.8	12.2	1.6	+3.0	1323	781	418	+124	624	217	354	+ 53	71	46	14	+11	-	-	-	-	-	-	-
	1	49.0	-	10.2	1.1	-	-	466	419	-	-	45	542	-	-	46	13	-	9.7	3.7	5.2	7.4	4.1	3.3	4.9
A. Ha. 75 yrs.	2	48.9	14.5	10.8	1.4	+2.3	1181	674	554	- 47	565	38	573	- 46	65	46	16	+ 3	-	-	-	-	-	-	-
	3	49.2	14.5	11.2	1.1	+2.2	1181	638	530	+ 13	565	33	544	- 12	65	47	16	+ 2	10.0	3.6	6.1	7.9	4.6	3.3	4.9
	4	49.2	14.5	11.2	1.1	+2.2	1181	668	507	+ 6	565	27	513	+ 25	65	51	15	- 1	-	-	-	-	-	-	-
	5	49.9	12.8	10.5	1.4	+0.9	1067	588	558	- 59	563	23	534	+ 6	60	48	18	- 6	10.4	3.6	5.3	7.2	4.2	3.0	4.7
Stilbestrol	6	49.0	14.5	10.3	1.3	+2.9	1181	578	489	+114	565	25	474	+ 66	65	48	16	+ 1	8.6	3.1	4.8	6.9	3.7	3.2	4.6
(5 mg./day)	7	48.7	14.5	12.1	1.5	+0.9	1181	643	580	- 42	565	22	506	+ 37	65	51	25	-11	-	-	-	-	-	-	-
	8	48.7	14.5	11.8	2.1	+0.6	1181	623	612	- 54	565	21	511	+ 33	65	44	24	- 3	9.6	3.0	5.1	6.9	3.7	3.2	4.5
	9	48.4	14.5	11.7	1.4	+1.4	1181	619	502	+ 60	565	26	431	+108	65	44	17	+ 4	10.1	2.7	5.6	6.9	3.8	3.1	5.0
	10	47.8	14.5	12.4	1.6	+0.5	1181	713	532	- 64	565	34	521	+ 10	65	50	16	- 1	-	-	-	-	-	-	-
	11	47.2	14.5	12.1	1.6	+0.8	1181	698	493	- 10	565	36	482	+ 47	65	46	21	- 2	9.1	3.0	5.3	6.9	3.8	3.1	4.4
	12	47.0	14.5	12.3	1.9	+0.3	1181	694	590	-103	565	33	590	- 58	65	52	18	- 5	-	-	-	-	-	-	-

All periods 5 days in length. *Bodansky Units.

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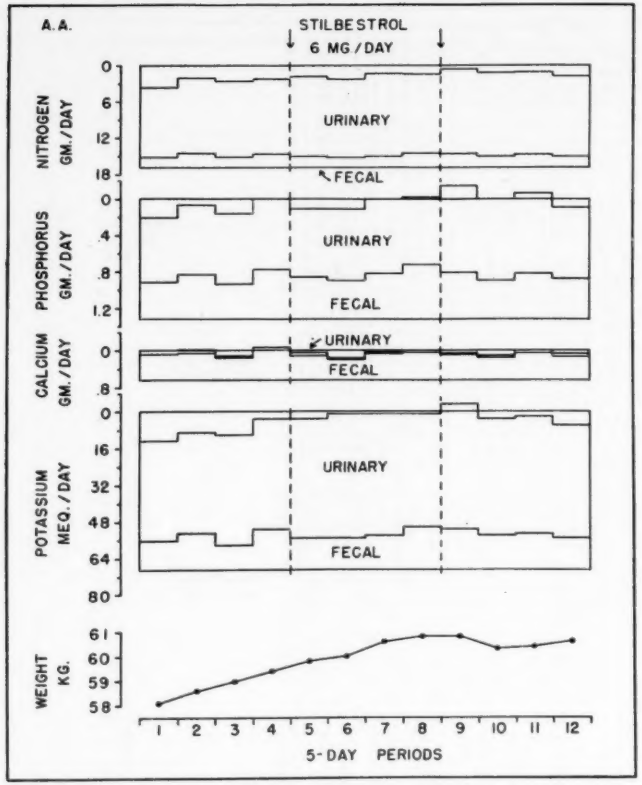

FIG. 1. Subject A.A. Age 77. Effect of stilbestrol administration (6.0 mg./day) on nitrogen, potassium, calcium, and phosphorus balances and body weight. The balance charts in figures 1-6 are plotted in the following manner: Intake is plotted downward from the zero line, fecal excretion is plotted upward from the intake line, and urinary excretion is plotted upward from the fecal output level. Periods extending above the zero line indicate negative balances.

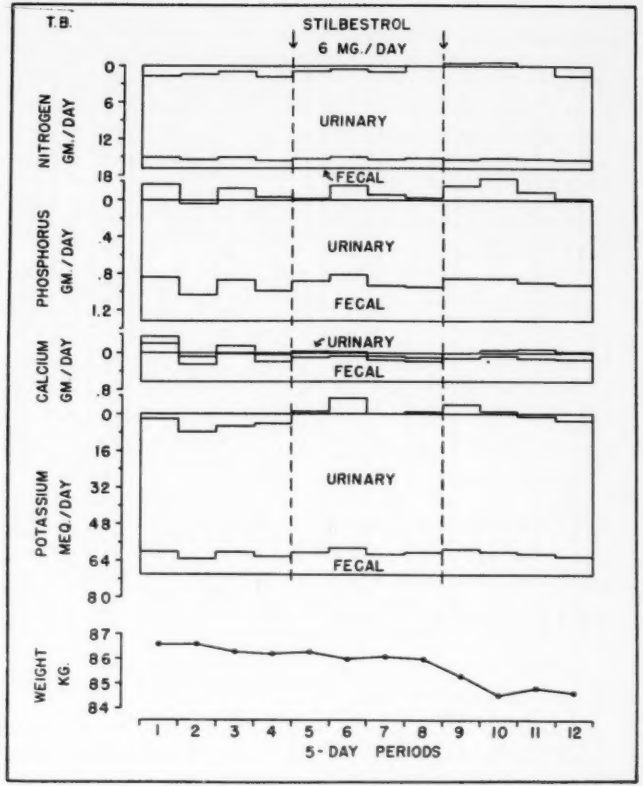

FIG. 2. Subject T.B. Age 73. Effect of stilbestrol administration (6.0 mg./day) on nitrogen, potassium, calcium, and phosphorus balances and body weight.

excretion is plotted upward from the intake line, and urinary excretion is plotted upward from the fecal output level. Periods extending above the zero line indicate negative balances.

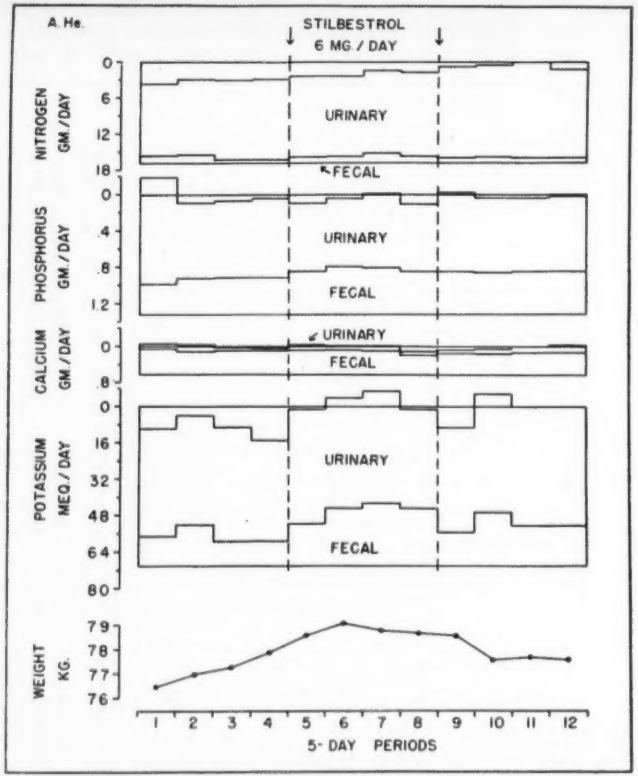

FIG. 3. Subject A.He. Age 73. Effect of stilbestrol administration (6.0 mg./day) on nitrogen, potassium, calcium, and phosphorus balances and body weight.

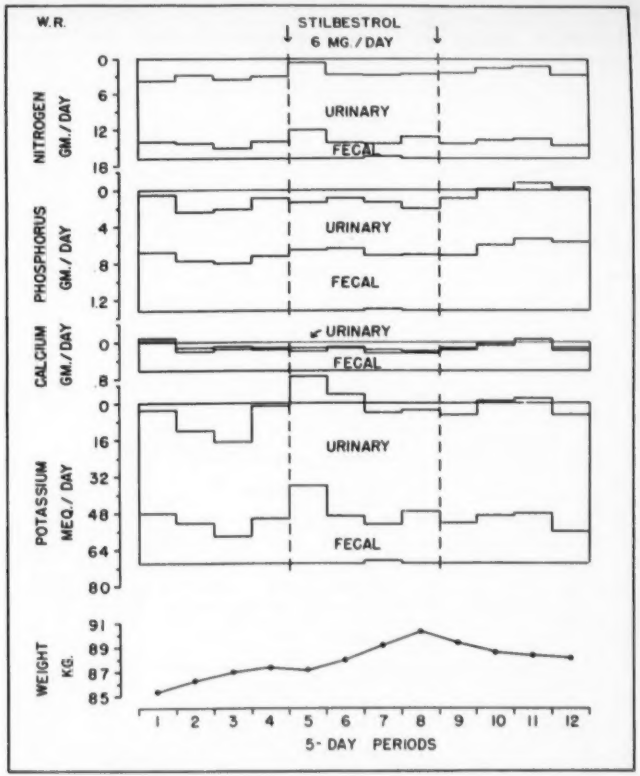

FIG. 4. Subject W.Ra. Age 82. Effect of stilbestrol administration (6.0 mg./day) on nitrogen, potassium, calcium, and phosphorus balances and body weight.

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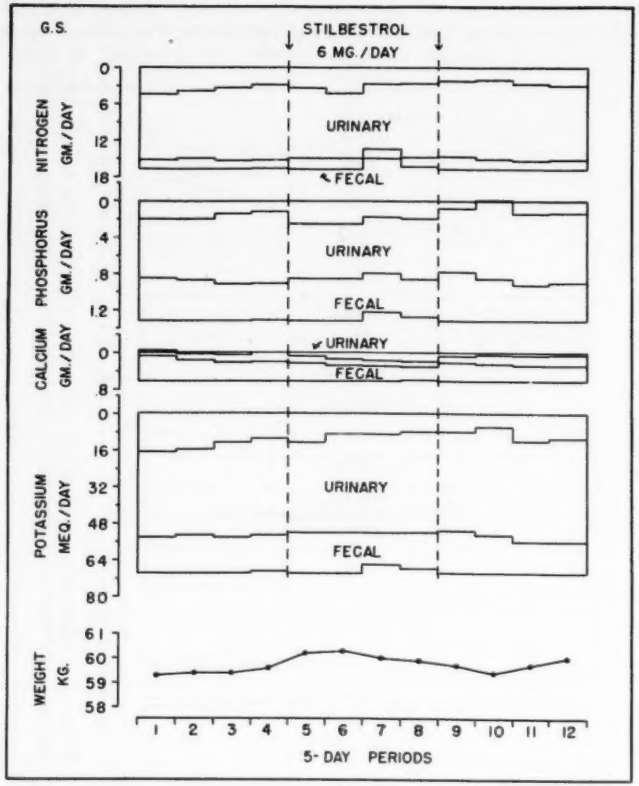

FIG. 5. Subject G.S. Age 70. Effect of stilbestrol administration (6.0 mg./day) on nitrogen, potassium, calcium, and phosphorus balances and body weight.

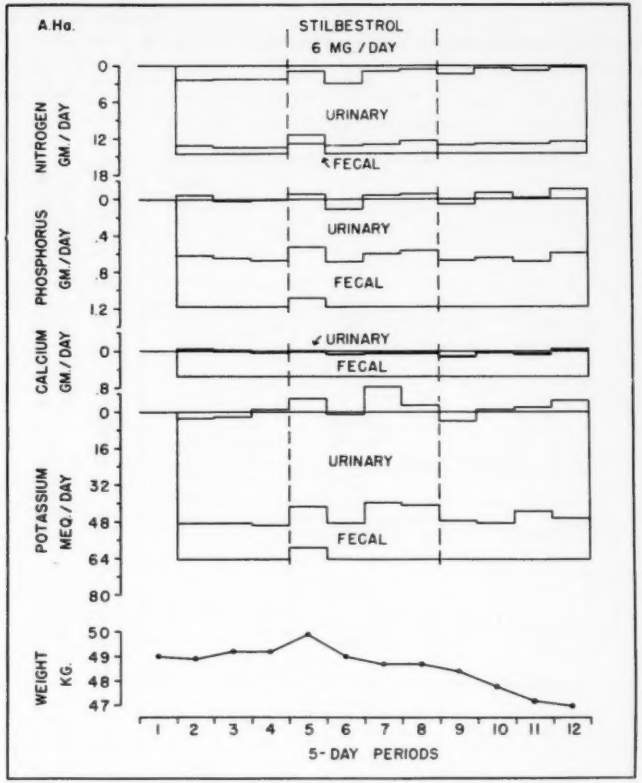

FIG. 6. Subject A.Ha. Age 75. Effect of stilbestrol administration (6.0 mg./day) on nitrogen, potassium, calcium, and phosphorus balances and body weight.

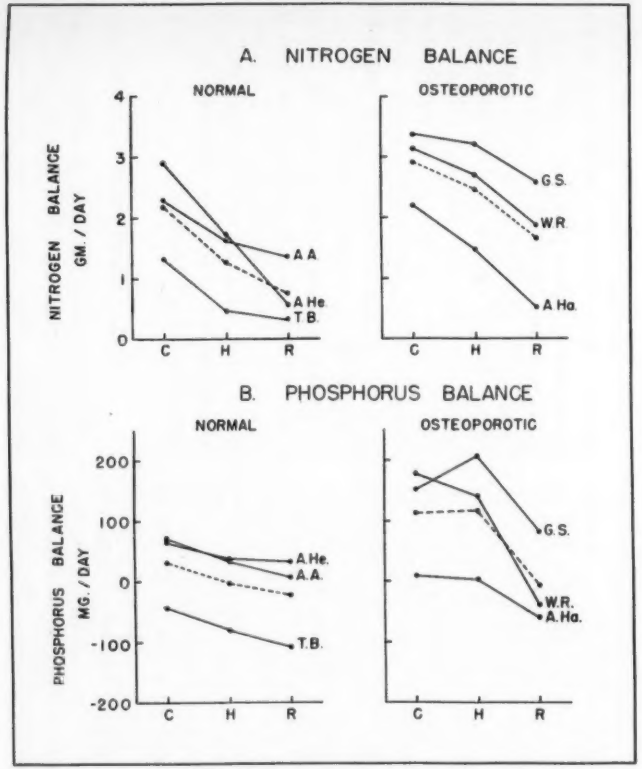

FIG. 7. Average effects of administration of stilbestol on nitrogen (A) and phosphorus (B) balances in normal and osteoporotic males.
C—mean of last 3 control periods
H—mean of last 3 treatment periods
R—mean of last 3 post-treatment periods. ---- average for 3 subjects plotted.

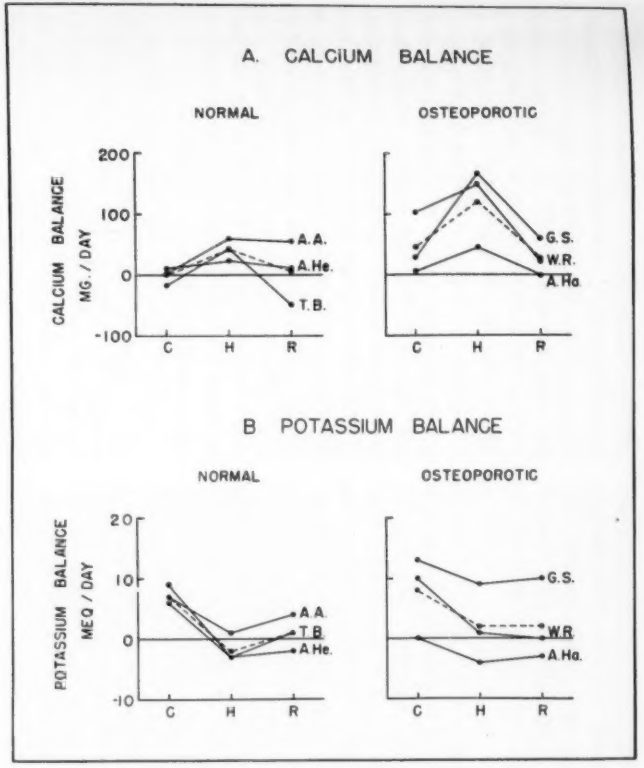

FIG. 8. Average effects of administration of stilbestrol on calcium (A) and potassium (B) balances in normal and osteoporotic males.
C—mean of last 3 control periods
H—mean of last 3 treatment periods
R—mean of last 3 post-treatment periods. ---- average for 3 subjects plotted.

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tic subjects than the non-osteoporotic in all circumstances. In all subjects, the progressive decrease in nitrogen retention was due primarily to increasing urinary excretion of nitrogen with little or no change in fecal excretion.

Phosphorus Balance:—All subjects except 1 normal (T.B.) were in positive phosphorus balance during the initial control periods. All the subjects showed a progressive reduction in phosphorus balance in the recovery periods as contrasted with the original control period (fig. 7B). Among the normal subjects, there was no evidence of any effect of stilbestrol administration on the general downward trend. However, 1 of the osteoporotic subjects showed an actual increase, and the other 2 a positive deviation from the trend line during the periods of hormone administration. The average phosphorus retention under all circumstances was greater in the subjects with osteoporosis than in those without.

Calcium Balance:—During the control periods, the normal subjects were close to equilibrium (−17 to +11, mean +1 mg. Ca./day). In contrast, the 3 osteoporotic subjects were retaining calcium (6 to 103 mg./day) to some extent under the dietary stimulus alone. When stilbestrol was administered, a small increase in calcium retention occurred in the normal subjects (average 42 mg./day). In contrast, the average retention of calcium in the osteoporotic subjects rose to an average of 120 mg./day, but fell to an average of 27 mg./day when the hormone stimulus was discontinued (fig. 8A). The increase in calcium retention during hormone administration was associated with a fall in urinary calcium excretion in both normal and osteoporotic subjects since the average daily urine volume fell from control levels of 1383 cc./24 hrs. to 1177 cc./24 hrs. during hormone administration (returning to 1224 cc./24 hrs. in the post-hormone periods). It was possible that the reduced urinary loss of calcium was simply a reflection of the reduced urine volume. However, calculations show that during stilbestrol administration, the concentration of calcium in the urine also diminished in all 6 subjects. The average urinary calcium concentration was 8.20 mg./100 cc. during control periods; 6.22 mg./100 cc. during the hormone administration, and 9.65 mg./100 cc. during the post-treatment period.

Potassium Balance:—Although all subjects except 1 (A.Ha.) were in positive potassium balance at the beginning of the study, there was a trend toward a decrease in the retention of potassium during the course of the study (fig. 8B). In 3 of the subjects, there was a slight negative balance both during and following the administration of stilbestrol. All subjects showed an augmentation of the downward trend in potassium retention during admininstration of stilbestrol.

Weight:—All of the subjects except 1 (T.B.) showed an average net gain in weight during the course of the experiment. The increment in weight during the stilbestrol administration was greater than during the control periods, except for subject, T.B., and all subjects showed a reduction in weight when the hormone administration was discontinued.

Serum Changes:—There were no striking changes during the course of the study in any of the serum values with the exception of a significant drop in the level of serum alkaline phosphatase in subjects W.Ra. and T.B. during therapy, with a rise to control values in the post-therapy periods. The other changes were: a slight fall in serum phosphorus in A.Ha., and a fall in serum calcium in A.He. There were no distinct trends in either of the 2 groups of patients.

Clinical Effects:—All 6 patients noted breast tenderness after seven to ten days of stilbestrol administration and in 2 subjects, W.Ra. and A.Ha., it was thought that increased breast tissue was palpable by the sixteenth day of therapy.

Discussion

The previously reported (4) ability of aged males to store nitrogen, phosphorus, and potassium when high intake levels are pro-

vided was confirmed. There was no evidence that stilbestrol had any additional influence on the nitrogen retention in the subjects without diminisable osteoporosis where nitrogen storage was being produced by a high protein intake. Only if one is willing to accept a small positive deviation from the over-all downward trend as evidence of an effect can one ascribe any influence of stilbestrol on the nitrogen retention of even the osteoporotic subjects. At best, the influence was very slight. On the average, the subjects with osteoporosis responded to the dietary stimulus with a greater retention of nitrogen than did the normal subjects.

During the control periods, the average potassium retention for all subjects was 7.7 mEq./day as compared with a theoretic retention of 6.9 mEq./day calculated only on the basis of the nitrogen retention (table 5). During the periods of stilbestrol administration, the potassium retention fell so that a discrepancy between the actual and theoretic retentions developed. Since the patients were in positive nitrogen balance during these periods, it is improbable that the increased potassium loss can be ascribed to tissue destruction.

All subjects, except 1 (T.B.), were in positive phosphorus balance throughout the experiment. The evidence supports the conclusion that, on the average, stilbestrol administration increased the phosphorus retention in the osteoporotic but not in the normal subjects. In this respect, the phosphorus and calcium retentions are in agreement.

When theoretic phosphorus balances were calculated on the basis of the retentions of nitrogen and calcium, the results were disappointing in that the actual phosphorus retentions were all lower than the theoretic values. Examination of the experimental data failed to reveal an explanation for the observed discrepancies which were sometimes as great as 100 mg./day.

In the osteoporotic subjects, the administration of stilbestrol was accompanied by an increased retention of calcium without a significant alteration in the positive nitrogen

TABLE 5
THEORETIC POTASSIUM BALANCE BASED ON NITROGEN RETENTION
(mEq. K RETAINED PER DAY FOR LAST 3 PERIODS FOR EACH EXPERIMENTAL CONDITION)

Subject	Control mEq./day		Hormone mEq./day		Recovery mEq./day	
	Theoretic K	Observed K	Theoretic K	Observed K	Theoretic K	Observed K
A. A.	6.3	7.3	5.7	1.0	3.7	3.6
T. B.	3.6	5.3	1.2	−2.6	.9	1.0
A. He.	7.8	9.3	4.6	−3.3	1.5	−2.0
W. Ra.	8.5	10.0	7.3	1.0	5.0	.7
G. S.	9.1	13.3	8.6	8.7	6.9	9.6
W. Ha.	6.0	1.3	3.9	−4.3	1.5	−2.6
Mean mEq./day	6.9	7.7	5.2	.08	3.2	1.7
Difference (Theoretic-observed)		+.8		−5.1		−1.5

balance stimulated by a relatively high protein intake. The effect of stilbestrol (in comparable dosages) of decreasing urinary excretion of calcium and phosphorus, and to a lesser extent fecal excretion of calcium, is in agreement with the observations reported by Albright and associates (1) and again more recently by Anderson and Reifenstein (3) in females with postmenopausal osteoporosis. Anderson also emphasized the lack of any effect upon nitrogen retention.

Since the stilbestrol administration increased calcium retention without a measurable increase in nitrogen retention, it is tempting to infer that the hormone enhances calcification by virtue of its action on the calcium deposition process rather than by stimulation of protein matrix formation. The fact that the magnitude of nitrogen and potassium retention tended to decrease during hormone administration is also in accord with this hypothesis. Unfortunately, the data of this study cannot be offered as proof, since the amount of nitrogen retention required for the observed calcium retentions is so small that it could be undetected by the metabolic balance techniques. Nevertheless, this experiment shows that stilbestrol can influence calcium retention without serving as a marked stimulus to nitrogen retention.

The fact that the non-osteoporotic individuals did not increase calcium storage appreciably during stilbestrol therapy may merely reflect the fact that there was no need for calcium retention in these individuals. These individuals did demonstrate decreases in urinary excretion of calcium, so that this action of the steroid probably does not depend upon calcium stores. No appreciable decrease of fecal excretion of calcium occurred. Calcium excretion by way of the gastrointestinal tract is considered to reflect body demands (5)[1] and during rapid bone repair, fecal calcium is decreased (2).

The one osteoporotic individual, A.Ha., who did not demonstrate a marked change in calcium retention, did demonstrate a decrease in urinary excretion and to a certain extent a decrease in fecal excretion. These changes were inconstant although the direction of change was for the most part towards increased retention. An explanation of his failure to demonstrate as marked a change as W.Ra. and G.S. may reside in the realm of dose-response possibilities, or may merely be a reflection of the fact that the spectrum of osteoporotic individuals is broad and A.Ha. represents a less reactive type. There were no clinical features of his disease to suggest the nature of this difference.

SUMMARY

1. Six aged males, 3 with and 3 without roentgenologic evidence of osteoporosis, were studied under metabolic balance conditions, before, during, and after the administration of stilbestrol, 6.0 mg./day for twenty days.

2. Stilbestrol did not increase nitrogen retention in the subjects who were already in positive nitrogen balance resulting from increased protein and caloric intakes.

3. Potassium retention was in accord with nitrogen retention during the control periods, but during stilbestrol administration, there was a reduction in potassium retention.

4. Stilbestrol decreased urinary excretion of calcium in all subjects, but promoted a significant net retention in only 2 subjects, both of whom suffered from osteoporosis. Phosphorus retention was not influenced by stilbestrol in the normal subjects, but was enhanced in the same 2 osteoporotic subjects who showed calcium retentions greater than 100 mg./day.

5. The observations indicate that stilbestrol serves as a stimulus to calcium retention and that these effects take place in the absence of the anabolic processes producing marked nitrogen retention.

We wish to acknowledge our indebtedness to Alice Hay and Mae Griffin for the preparation and serving of the food and to Millard Starnes, Margaret Bellistri, and Arthur Dinan for technical assistance. Thanks are also due Mrs. Elizabeth Strawn for supervision of the special nursing required in this study. Dr. Milton Landowne offered valuable criticisms and suggestions in the interpretation of the data.

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DIURNAL, AGE, AND SEX CHANGES IN THE SODIUM AND POTASSIUM CONCENTRATION OF HUMAN SALIVA

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RECENT evidence has revealed the human salivary Na/K level to be an indication of the level of adrenal cortical function (2, 6, 7, 8, 10, 23, 25). This finding makes necessary a wider knowledge of the variation of the salivary Na/K under various physiologic conditions. Accordingly, an investigation was undertaken on the variation of the Na and K concentration of unstimulated saliva in persons of different age and sex, and at different times of the day. The physiologic significance of these findings will be discussed.

METHODS

The saliva collected for this study was of the mixed unstimulated type, that is, that liquid which normally collects and is swallowed when food or other substances are *not* present in the mouth. The sample of saliva was centrifuged and aliquots of the supernatant fluid were withdrawn and diluted 1:25 with distilled water.

Sodium and potassium concentrations were determined by a propane-burning Perkin Elmer flame photometer (Model No. 52A), using the direct intensity procedure. A series of Na standards varying in concentration from 0.04 to 2.20 mEq./l in steps of 0.02 mEq./l and a series of K standards ranging from 0.20 to 2.60 mEq/l in steps of 0.05 mEq. per litre were set up. The Na or K concentration in a sample of diluted saliva was determined by finding that standard which gave a dial reading closest to that of the unknown. The need for a calibration curve and the attendant errors due to the drifting of such a curve was therefore eliminated. By this method, an error was introduced in the determination of the Na concentration in the original sample of the undiluted saliva of not more than 0.25 mEq./l and of not more than 0.63 mEq./l in the case of the K.

Details of the characteristics of the flame photometer used in the present study have been described elsewhere (4).

To test for the presence of substances in saliva which might possibly interfere with the accurate determination of its Na or K concentration, samples of unstimulated saliva obtained from several persons were pooled and diluted with variable amounts of distilled water (table 1). The assumption was that if an interfering substance were present, then by diluting it, a point would be reached where its interference would disappear. If this were so, the estimation of the original salivary Na and K concentration from differently-diluted specimens of same saliva would be different. Other tests were carried out to see whether the addition to diluted saliva of known amounts of Na or K could be

TABLE 1
THE EFFECT OF DILUTING HUMAN RESTING SALIVA ON THE DETERMINATION OF ITS Na AND K CONCENTRATION

Volume of Pooled Saliva (ml.)	Volume of Distilled Water (ml.)	Original Salivary Concentration (mEq./l)	
		Sodium	Potassium
1	49	12.00	24.50
1	24	12.13	23.75
3	47	12.00	23.84

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reliably recovered and whether the addition of a certain amount of Na interfered with the determination of the K or vice versa (table 2).

TABLE 2
THE RECOVERY OF SODIUM AND POTASSIUM ADDED TO HUMAN RESTING SALIVA, AND THE DETERMINATION OF THE SODIUM CONCENTRATION IN THE PRESENCE OF ADDED POTASSIUM AND VICE VERSA

Electrolyte Added (mEq./1)	Electrolyte Found (mEq./1) Na	K	% Recovery of Added Electrolyte
None	0.280	0.855	—
None	0.270	0.885	—
.08 Na	0.350	0.880	93.4 Na
.12 Na	0.400	0.895	104.2 Na
.20 Na	0.480	0.890	102.5 Na
.50 K	0.275	1.400	103.0 K
.90 K	0.275	1.770	98.3 K

As a further check on the reliability of the method, the sodium and potassium concentrations were determined in the mixed resting saliva of 4 persons both by the direct intensity method and by the internal standard procedure which involved the addition of lithium salts to the standard and unknown solution (1). The mean difference in the values obtained by these two techniques was 3.4 per cent for the sodium and 0.5 per cent for the potassium (table 3). These tests showed that the Na and K of human mixed saliva could be measured with a good degree of accuracy by direct intensity flame photometry.

One hundred and eight persons, 52 men and 56 women, ranging in age from 5 to 99 years old, were the subjects of this investigation. All subjects were apparently healthy. Attempts were made to collect one specimen of approximately 4 ml. saliva from each subject before each meal and at bedtime. The before breakfast samples were collected immediately upon awakening. The subjects did not eat, drink, smoke, or nap for an hour preceding the collection of the sample at the other times of the day, but they ate their usual meals at mealtime. A complete set of 4 specimens was obtained from 101 subjects, the remaining 7 subjects providing 1, 2, or 3 samples.

Each subject's data can be seen in table 4, while the data of the 101 subjects who provided a complete set of 4 specimens are summarised in table 5. The significance of differences was tested by the t test and by the chi-square test, a difference of 0.05 being considered significant (19).

RESULTS AND DISCUSSION

Diurnal Variation.—A definite diurnal rhythm was found to occur in the salivary Na/K, a rhythm which was chiefly due to the sodium, the potassium remaining relatively constant. The salivary Na/K was significantly higher before breakfast than at any other time of the day (table 5), in 79 of the 101 subjects who provided a complete set of 4 specimens (table 4). In 51 subjects the minimum in the salivary Na/K occurred before lunch while in 33 others the before supper sample had the lowest values. There was a tendency for the values to rise before re-

TABLE 3
COMPARISON OF THE DIRECT INTENSITY AND INTERNAL STANDARD PROCEDURES FOR THE DETERMINATION OF THE SODIUM AND POTASSIUM CONCENTRATION OF HUMAN RESTING SALIVA.

Procedure	Subject 1 Na (mEq./1)	K	Subject 2 Na (mEq./1)	K	Subject 3 Na (mEq./1)	K	Subject 4 Na (mEq./1)	K
Direct Intensity	5.00	25.00	4.00	22.50	4.00	22.50	11.25	18.75
Internal Standard	4.75	25.50	4.00	22.50	3.75	22.50	10.75	18.75
% Difference	5.0	2.0	0	0	6.3	0	2.3	0

TABLE 4

THE SODIUM AND POTASSIUM CONCENTRATION AND THE SODIUM/POTASSIUM OF HUMAN MIXED UNSTIMULATED SALIVA.

Subject	Age Yrs.	Sex	Sodium (mEq./l)				Potassium (mEq./l)				Sodium/Potassium			
			Before Breakfast	Before Lunch	Before Supper	Before Retiring	Before Breakfast	Before Lunch	Before Supper	Before Retiring	Before Breakfast	Before Lunch	Before Supper	Before Retiring
BA	5	M	23.25	4.50	4.25	4.25	37.00	15.50	17.00	18.25	.63	.29	.25	.23
JS	6	M	6.50	7.50	5.50	6.00	22.50	22.00	17.50	18.75	.29	.34	.31	.32
ME	7	M	14.75	7.00	5.00	7.00	26.25	23.75	21.25	21.25	.56	.29	.24	.33
BA	8	M	11.00	4.00	6.50	3.50	22.50	18.25	18.75	17.75	.49	.22	.35	.20
TE	8	F	14.00	6.75	15.00	12.00	19.00	18.75	16.25	15.75	.74	.36	.92	.76
BZ	10	M	5.75	4.50	5.75	5.50	26.25	25.25	24.75	27.50	.22	.18	.23	.20
MF	10	M	18.00	35.50	18.25	18.00	25.00	25.00	17.00	18.00	.72	1.42	1.07	1.00
RA	10	F	4.50	12.50	9.50	11.75	10.00	17.00	18.25	17.50	.45	.74	.51	.67
SG	10	F	5.50	5.00	5.25	5.50	18.75	19.75	20.50	18.75	.29	.25	.26	.29
AD	10	F	11.75	10.00	8.50	16.50	22.75	21.25	21.25	20.50	.52	.47	.40	.80
CT	10	F	8.00	3.50	3.25	4.50	30.00	25.00	22.50	19.00	.27	.14	.14	.24
SF	11	F	13.00	6.50	5.00	4.75	32.50	33.75	27.50	29.50	.40	.19	.18	.16
MD	11	F	8.50	5.50	6.50	6.25	17.00	23.25	17.50	18.25	.50	.24	.37	.34
AA	14	M	5.75	5.00	5.00	5.25	22.25	24.00	23.75	23.75	.26	.21	.21	.22
PW	14	M	14.25	10.00	7.50	5.75	26.25	26.00	22.25	26.25	.54	.38	.34	.22
AZ	14	F	21.00	4.50	5.75	12.00	23.50	27.00	25.00	28.50	.89	.17	.23	.42
MP	17	M	12.25	8.00	8.00	10.00	18.75	20.00	20.50	21.00	.65	.40	.39	.48
MK	17	F	14.50	9.75	8.00	9.00	20.00	17.50	19.75	16.75	.73	.56	.41	.54
PF	18	F	15.25	8.75	7.25	11.75	21.50	24.00	21.50	21.75	.71	.36	.34	.54
LC	19	M	20.00	4.00	4.50	6.25	30.00	26.25	23.75	22.00	.67	.15	.19	.28
MP	20	F	6.50	4.00	7.75	14.00	17.50	21.00	18.75	19.25	.37	.19	.41	.73
SS	21	F	13.00	4.50	5.00	6.25	27.00	22.25	24.50	19.50	.48	.20	.20	.32
PB	22	F	16.50	5.00	4.50	6.50	18.75	19.50	22.00	21.75	.88	.26	.20	.30
TB	23	M	14.50	11.75	18.00	18.25	15.25	15.25	15.25	13.75	.95	.77	1.18	1.33
HW	23	M	10.25	5.25	6.50	7.00	19.00	20.00	17.00	16.50	.54	.26	.38	.42
GB	23	M	17.50	7.25	9.00	7.75	22.25	24.50	22.00	23.75	.79	.30	.41	.33
JR	24	F	12.25	6.50	21.00	6.00	17.50	22.50	25.25	20.00	.70	.29	.83	.30
TB	25	M	16.25	10.00	11.50	13.50	17.25	19.00	17.50	16.25	.94	.53	.66	.83
BA	26	F	10.75	6.25	4.75	7.50	19.00	19.75	17.25	20.75	.57	.32	.28	.36
RQ	27	M	9.50	9.75	8.25	11.00	21.75	19.25	21.25	26.25	.44	.51	.39	.42
ES	28	M	28.75	12.25	7.00	7.50	35.75	34.50	27.50	33.75	.80	.36	.25	.22
MP	30	F	21.25	6.00	4.00	4.00	25.00	22.25	27.75	22.75	.85	.27	.14	.18
LG	30	F	16.25	4.75	5.25	7.25	22.50	21.25	19.50	21.75	.72	.22	.27	.33
PG	31	M	14.50	5.25	7.25	5.25	27.00	21.00	26.75	21.25	.54	.25	.27	.25
BG	32	M	19.25	3.75	6.00	11.75	27.00	22.50	23.75	28.75	.71	.17	.25	.41
TM	32	F	42.50	30.00	22.50	30.25	16.75	13.75	14.25	14.50	2.54	2.18	1.58	2.09
JC	32	F	8.75	2.75	3.25	4.00	27.00	23.75	25.00	24.50	.32	.12	.13	.16
LG	32	F	18.00	3.75	5.25	5.75	24.50	19.25	20.00	20.00	.73	.19	.26	.29
DB	35	M	28.00	7.25	11.25	10.00	20.00	19.50	18.50	20.75	1.40	.37	.61	.48
PH	35	F	16.25	3.75	4.75	5.50	33.50	22.25	25.00	25.75	.49	.17	.19	.21
DK	37	M	7.25	5.00	6.00	9.75	26.25	23.00	22.00	20.75	.28	.22	.27	.47
AO	38	M	14.25	5.50	8.00	5.50	29.75	25.00	37.50	25.25	.48	.22	.21	.22
MR	38	F	26.50	8.50	10.00	10.75	20.00	30.00	35.00	19.75	1.33	.28	.29	.54
MB	40	M	21.50	15.25	15.75	5.75	32.00	21.25	24.75	21.75	.67	.72	.64	.26
MB	40	F	24.00	15.00	8.50	14.50	23.75	23.50	23.50	25.75	1.01	.64	.36	.56
AS	41	F	9.50	5.00	4.50	6.75	14.75	18.00	16.00	14.25	.64	.28	.28	.47
AW	42	F	5.50	3.50	3.00	9.00	21.00	19.25	19.00	25.00	.26	.18	.16	.36
CH	43	M	24.00	6.00	9.25	10.50	23.00	19.75	18.50	18.75	1.04	.30	.50	.56
KS	45	F	30.00	4.50	6.00	—	37.50	21.25	19.50	—	.80	.21	.31	—
LB	47	F	11.25	4.50	6.25	8.00	17.50	18.50	18.25	18.25	.64	.24	.34	.44
PP	48	M	10.00	17.25	12.00	11.25	20.00	21.00	21.25	25.00	.50	.82	.56	.45
MP	48	F	18.75	7.25	7.50	12.00	33.25	25.00	28.50	28.00	.56	.29	.26	.43
AR	49	M	36.25	16.25	10.25	20.75	43.75	50.00	30.00	43.75	.83	.33	.34	.47
RA	49	M	24.00	12.00	13.00	11.50	26.25	21.75	19.75	17.75	.91	.55	.66	.65

TABLE 4.—(Continued)

MP	48	F	18.75	7.25	7.50	12.00	33.25	25.00	28.50	28.00	.56	.29	.26	.43
AR	49	M	36.25	16.25	10.25	20.75	43.75	50.00	30.00	43.75	.83	.33	.34	.47
RA	49	M	24.00	12.00	13.00	11.50	26.25	21.75	19.75	17.75	.91	.55	.66	.65

TABLE 4.—(Continued)

Subject	Age Yrs.	Sex	Sodium (mEq./l)				Potassium (mEq./l)				Sodium/Potassium			
			Before Breakfast	Before Lunch	Before Supper	Before Retiring	Before Breakfast	Before Lunch	Before Supper	Before Retiring	Before Breakfast	Before Lunch	Before Supper	Before Retiring
FR	50	F	11.75	4.00	4.25	9.50	21.00	22.75	19.75	18.50	.56	.18	.22	.51
AA	51	F	11.50	6.50	6.00	7.00	22.25	23.25	18.25	21.25	.52	.28	.33	.33
AK	54	M	55.00	30.75	23.00	20.75	50.00	35.25	42.75	29.25	1.10	.87	.54	.71
ZL	55	M	8.25	4.00	30.00	6.50	25.00	20.50	35.50	20.25	.33	.20	.85	.32
RA	55	F	28.75	9.50	8.25	10.50	31.00	22.00	23.00	23.75	.93	.43	.36	.44
AC	56	M	50.00	14.50	15.00	17.00	31.00	37.00	37.25	26.25	1.61	.39	.40	.65
BT	58	M	31.25	19.50	16.50	10.50	22.50	22.50	22.50	22.25	1.39	.87	.73	.47
LD	58	F	6.25	2.50	5.00	3.00	22.50	27.75	30.00	26.75	.28	.09	.17	.11
BG	59	M	26.25	6.00	6.00	7.00	17.50	20.75	19.00	20.75	1.50	.29	.32	.34
LL	59	M	24.25	13.75	11.50	8.50	29.50	42.50	40.75	32.50	.82	.32	.28	.26
BS	59	F	15.50	3.25	4.75	6.75	28.75	21.25	20.00	18.75	.54	.15	.24	.36
LD	62	M	40.00	——	——	——	20.00	——	——	——	2.00	—	—	—
WJ	62	M	50.00	27.50	25.00	17.50	37.75	38.50	33.75	34.50	1.32	.71	.74	.51
II	62	F	11.50	3.50	4.50	18.00	22.00	20.25	18.50	23.75	.52	.17	.24	.76
OB	62	F	14.50	9.00	8.75	8.50	23.75	28.75	26.25	21.50	.61	.31	.33	.40
JS	63	M	27.50	10.25	6.50	15.00	22.50	20.00	20.00	21.75	1.22	.51	.33	.69
ES	63	F	10.50	5.75	6.50	6.00	20.00	19.25	18.75	19.25	.53	.30	.35	.31
SM	64	M	11.25	3.75	4.25	7.50	27.00	21.50	27.50	27.75	.42	.17	.15	.27
JO	65	M	12.50	4.50	5.75	7.25	22.00	22.50	22.25	26.25	.57	.20	.26	.27
PR	66	M	10.00	9.00	4.75	4.00	27.50	29.75	12.25	13.25	.36	.30	.39	.30
JT	66	F	23.50	5.75	6.00	7.50	33.75	19.75	23.25	18.00	.70	.29	.26	.42
FC	66	F	9.25	5.00	5.00	6.50	33.75	25.75	31.00	33.00	.27	.19	.16	.20
ND	67	M	15.25	6.75	6.25	8.75	24.00	33.75	28.25	28.50	.64	.20	.22	.31
MT	67	F	11.75	4.25	5.50	6.50	15.75	17.50	18.75	16.50	.75	.24	.29	.39
CM	67	F	40.00	17.25	——	11.00	60.00	60.00	——	41.25	.67	.29	—	.27
CC	70	M	38.50	15.50	24.50	28.75	22.50	21.25	21.25	21.25	1.71	.73	1.15	1.35
GH	70	M	8.50	7.50	5.50	7.00	20.00	24.00	22.00	12.50	.43	.31	.25	.56
JA	71	M	12.25	7.50	7.50	5.50	21.25	25.00	24.50	22.00	.58	.30	.31	.25
FS	71	F	16.25	10.00	8.75	23.50	55.00	56.25	50.00	60.00	.30	.18	.18	.39
MC	73	F	21.00	12.25	8.75	10.75	18.75	21.25	25.00	38.75	1.12	.58	.35	.28
ML	73	F	——	16.50	13.25	——	——	50.50	33.75	——	—	.33	.39	—
IB	74	M	28.75	28.75	40.00	32.25	21.25	26.50	38.75	28.75	1.35	1.08	1.03	1.12
HB	74	M	10.00	4.75	7.50	11.25	22.00	23.50	22.75	25.50	.45	.20	.33	.44
FB	74	F	23.00	12.50	13.00	15.50	50.00	47.50	50.00	47.50	.46	.26	.26	.33
HF	78	F	14.25	10.50	17.50	16.00	27.50	36.00	48.00	42.50	.52	.29	.36	.38
SC	78	F	13.50	10.00	10.00	10.00	24.75	18.25	18.75	21.00	.55	.55	.53	.48
HB	79	M	31.25	8.00	9.00	14.00	28.25	26.25	31.00	36.50	1.11	.30	.29	.38
CB	79	F	21.25	8.00	5.75	8.50	35.00	38.00	29.50	30.00	.61	.21	.19	.28
EG	80	F	9.00	5.25	6.25	6.25	22.50	25.00	21.25	22.75	.40	.21	.29	.27
YE	81	M	8.75	8.00	8.00	9.50	21.00	24.50	23.75	23.75	.42	.33	.34	.40
BK	83	M	14.00	12.00	7.00	14.00	20.00	18.00	19.00	17.50	.70	.67	.37	.80
JC	83	M	32.25	24.50	6.50	15.00	46.25	55.00	23.25	48.75	.70	.45	.28	.31
MW	83	F	23.75	10.00	9.50	——	35.00	25.00	25.00	——	.68	.40	.38	—
BG	83	F	24.75	4.25	8.50	——	25.50	13.75	32.50	——	.97	.31	.26	—
IG	84	M	22.00	16.25	15.75	12.75	19.50	27.75	22.50	23.75	1.13	.59	.70	.54
JC	84	M	50.00	——	——	23.25	46.25	——	——	63.75	1.08	—	—	.36
MS	84	F	19.50	8.25	8.00	9.50	50.25	37.25	41.50	39.25	.39	.22	.19	.24
ME	84	F	40.00	24.00	7.75	14.00	40.50	22.00	27.75	27.50	.99	1.09	.28	.51
AS	84	F	12.50	6.00	4.25	5.50	30.00	42.25	43.25	38.75	.42	.14	.10	.14
MP	85	F	17.50	6.50	4.50	8.00	31.50	34.25	33.75	43.25	.56	.19	.13	.19
SG	86	F	17.00	7.00	9.75	6.25	25.00	30.00	33.75	25.00	.68	.23	.29	.25
WW	87	M	8.25	5.75	5.50	5.50	28.25	26.00	25.00	29.25	.29	.22	.22	.19
AM	92	M	35.00	24.50	32.75	40.00	17.25	18.50	18.50	21.00	2.03	1.32	1.77	1.90
AH	99	F	10.75	8.00	2.25	11.25	23.75	23.50	7.50	23.75	.45	.34	.30	.47

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TABLE 5

THE SODIUM AND POTASSIUM CONCENTRATION AND THE SODIUM/POTASSIUM OF HUMAN MIXED UNSTIMULATED SALIVA.

Age Yrs.	Sex	No. of Subjects	Sodium				Potassium				Sodium/Potassium			
			Before Breakfast	Before Lunch	Before Supper	Before Retiring	Before Breakfast	Before Lunch	Before Supper	Before Retiring	Before Breakfast	Before Lunch	Before Supper	Before Retiring
			* ‡											
5–39	M	21	14.83±1.44	8.24±1.48	8.05±0.84	8.51±0.90	24.67±1.21	22.36±0.93	21.69±1.09	21.98±1.05	0.61±0.06	0.37±0.06	0.40±0.06	0.42±0.06
5–39	F	22	14.75±1.74	7.20±1.21	7.82±1.01	9.17±1.26	22.00±1.19	22.03±0.93	22.01±0.99	20.75±0.80	0.70±0.10	0.37±0.09	0.39±0.07	0.48±0.09
40–99	M	29	23.68±2.52	13.10±1.48	13.25±1.75	13.29±1.57	26.51±1.56	27.40±1.75	25.80±1.40	25.54±1.49	0.90±0.09	0.49±0.05	0.52±0.06	0.54±0.07
40–99	F	29	15.84±1.36	7.67±0.82	6.92±0.58	9.83±0.82	28.25±1.90	27.03±1.79	26.99±2.01	28.01±2.00	0.58±0.04	0.30±0.04	0.27±0.03	0.37±0.03

* mean; ‡ standard error.

Statistical Analysis of Above Data:

Subjects	Sodium				Potassium				Sodium/Potassium			
	Before Breakfast vs.	Before Lunch	Before Supper vs.	Before Retiring	Before Breakfast vs.	Before Lunch	Before Supper vs.	Before Retiring	Before Breakfast vs.	Before Lunch	Before Supper vs.	Before Retiring
Men 5 to 39 yrs.	.01>P> .001		.9>P>.8		.2>P>.1		.10>P>.05		.01>P> .001		.6>P>.5	
Women 5 to 39 yrs.	P<0.001		.3>P>.2		P>.9		P=.3		.05>P> .02		.4>P>.3	
Men 40 to 99 yrs.	P<0.001		P>.9		.8>P>.7		.5>P>.4		P<0.001		.6>P>.5	
Women 40 to 99 yrs.	P<0.001		.10>P>.05		.7>P>.6		.7>P>.6		P<0.001		.2>P>.1	

	Sodium				Potassium				Sodium/Potassium			
	Before Breakfast	Before Lunch	Before Supper	Before Retiring	Before Breakfast	Before Lunch	Before Supper	Before Retiring	Before Breakfast	Before Lunch	Before Supper	Before Retiring
Men 5–39 vs. 40–99	.01>P>.001	.05>P>.02	.02>P>.01	.05>P>.02	.4>P>.3	.02>P>.01	.05>P>.02	.10>P>.05	P=0.01	.2>P>.1	.4>P>.3	.3>P>.2
Women 5–39 vs. 40–99	.6 >P>.5	.8 >P>.7	.5 >P>.4	.2 >P>.1	.01>P>.001	.02>P>.01	.05>P>.02	.01>P>.001	.3>P>.2	.5>P>.4	.2>P>.1	.3>P>.2
5–39 Men vs. Women	P>0.9	.9 >P>.8	P>0.9	.7>P>.6	.2>P>.1	.9>P>.8	.9>P>.8	.4>P>.3	.5>P>.4	P=1.00	P>.9	.6>P>.5
40–99 Men vs. Women	.01>P>.001	.01>P>.001	.01>P>.001	P=.05	.5>P>.4	.9>P>.8	.7>P>.6	.4>P>.3	.01>P>.001	.01>P>.001	.01>P>.001	.05>P>.02

tiring, 76 of the 101 subjects having intermediate values at this time of day (table 4). However, the rise that occurred in the salivary Na/K before retiring did not seem to be significant by t test (table 5). The expression of the results as a mean of several individuals, as in table 5, tended to obscure an actual rise in the salivary Na/K that did in fact occur before retiring in most individuals. This rise could be seen from the following: on the basis of chance alone, only 6 to 7 of the 101 subjects should have shown a pattern where both the before breakfast and before retiring Na/K values were higher than both the before lunch and before supper values. Actually 53 subjects showed such a pattern, a statistically significant finding. The data of the 7 subjects who failed to provide a complete set of 4 specimens had to be omitted from consideration here inasmuch as the diurnal change in the salvary Na and K from before breakfast to before retiring was not observed in them.

Inasmuch as these changes did not occur to the same extent in the salivary K concentration, this diurnal variation in the salivary Na could not have been due simply to a change in the saliva's content of water. This is a confirmation of an earlier finding on fewer subjects (9).

Was this diurnal variation in the salivary Na/K a function of the time of day or of the activity cycle of the person? To answer this, samples of saliva were collected before each meal and at bedtime for 3 consecutive days from a subject (R.A., male, age 49) adapted to working at night and sleeping during the day. He also showed a peak in the salivary Na/K before breakfast, a low point at lunch with a tendency for the values to rise by the time he was ready to retire, just as with the other subjects (table 6). However, he normally ate his breakfast in mid-afternoon, his lunch at 10:30 p. m., his dinner at about 6:30 a. m., and he retired at 8:00 a. m. Therefore, the salivary Na and Na/K diurnal variation seemed to be a function of the sleep-working cycle of the person and not of the time of the day.

That a reduction of activity such as occurs even during an hour's nap can cause the salivary Na/K to rise was seen from the following experiment on a hospitalized subject from whom samples of saliva were collected once daily before lunch on each of several days. The results showed very little variation in the salivary Na and K on most days except for days 3 and 7, when the patient took a short nap for about an hour before providing a saliva specimen (fig. 1). On these 2 days, there were distinct increases in the salivary Na. The K concentration also rose, but to a lesser extent than the Na so that the Na/K also increased on these days.

The following experiment was undertaken to test whether the rather sharp decline in the salivary Na/K that usually occurred between before breakfast and before lunch was due to the breakfast meal taken several hours prior to the collection of the before lunch specimen or to the sleep-waking pattern of the individual. Samples of saliva were col-

TABLE 6
DIURNAL VARIATION OF THE SALIVARY SODIUM AND POTASSIUM CONCENTRATION (mEq./l) OF A NIGHT WORKER

Time of Day	Sodium	Potassium	Sodium/Potassium
Before Breakfast at 3 p. m.	21.75 ± 2.76	25.17 ± 1.34	0.85 ± 0.07
Before Lunch at 10:30 p. m.	10.17 ± 0.93	22.58 ± 0.96	0.45 ± 0.05
Before Supper at 6:30 a. m.	14.25 ± 0.80	20.92 ± 0.65	0.68 ± 0.03
Before Retiring at 8 a. m.	13.42 ± 1.24	17.58 ± 0.44	0.76 ± 0.06

The above values are the mean and standard error of saliva samples collected on three consecutive days.

lected from 6 women and 3 men, before breakfast and before lunch on each of 3 days. After providing saliva specimens on the first

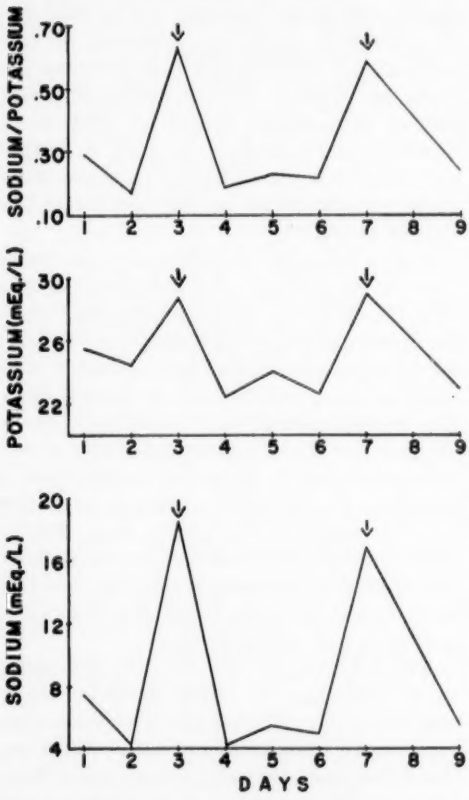

Fig. 1: The effect of a short nap on the Na, K, and Na/K of resting saliva. The arrows indicate the days when a nap was taken just befor the subject provided a saliva sample.

day, the subjects went on a complete fast of food and drink at around 6 o'clock in the evening and continued fasting for about 24 hours. Saliva samples were collected on the day of the fast and on the next day at the same time of the day as on the first day. The results showed that the salivary Na/K of each of the 9 subjects also declined between the usual before breakfast hour and the before lunch hour even though the meals usually taken at these times were omitted (table 7). This Na/K decline was due chiefly to the fact that the Na decreased more than did the K, although the latter also showed a decline in the experiment. Interestingly enough, although the diurnal decline in the salivary Na/K very definitely occurred on the day of the fast as on the other days, the decline was generally not as marked on the fasting day (table 7).

It is well known that the salivary Na/K increases as the rate of salivary secretion increases (5, 12) and possibly the higher Na/K in the before breakfast saliva was due to a faster rate of salivary secretion at this time. However, most of the 108 subjects of this study complained that providing 4 ml. of saliva took a longer time before breakfast than at the other times of the day; that is, the salivary secretion rate must have been slower before breakfast than at the other times. Therefore, the higher salivary Na and the Na/K observed before breakfast was not due to a faster rate of salivary secretion in the early morning.

Was the diurnal rhythm in the salivary Na/K a consequence of similar changes in the blood, from which the salivary Na and K must obviously have come? To answer this, the Na and K concentrations were determined in samples of serum and saliva collected simultaneously before breakfast and also before lunch from a 17-year old man on 2 consecutive days. Both the salivary Na and K concentration of the before lunch sample were lower than those of the before breakfast specimen (the Na more so than the K), but the serum concentration of these electrolytes remained virtually unchanged (table 8). That the salivary Na and K concentration could vary without a corresponding change in the serum Na and K concentration pointed to a selective action on the part of the salivary cells. Further support for this claim for selectivity was the fact that the salivary Na/K was usually less than 1 (table 5) while the serum Na/K was more than 20 times higher (14) and the fact that the salivary Na and K concentration were

TABLE 7
THE EFFECT OF A SHORT FAST ON THE HUMAN SALIVARY Na/K.

Subject	Age and Sex	Day Before Fast		Day of Fast		Day After Fast	
		Before Breakfast	Before Lunch	Before Breakfast	Before Lunch	Before Breakfast	Before Lunch
OK	26 F	0.88	0.29	0.75	0.39	0.55	0.24
RG	53 F	0.73	0.25	0.65	0.47	0.69	0.39
LG	32 F	0.47	0.23	0.54	0.41	0.53	0.29
BG	32 M	0.67	0.14	0.69	0.47	0.56	0.19
FD	57 F	0.26	0.06	0.48	0.29	0.23	0.14
ES	33 F	0.52	0.38	0.56	0.34	0.55	0.28
AO	37 M	0.58	0.21	0.55	0.40	0.46	0.21
JM	50 M	0.61	0.19	0.58	0.38	0.64	0.18
RB	47 F	0.70	0.34	0.71	0.58	0.66	0.46

TABLE 8
THE SODIUM AND POTASSIUM OF SPECIMENS OF BLOOD AND SALIVA COLLECTED SIMULTANEOUSLY FROM A 17-YEAR OLD MALE.

Day	Time of Day	Sodium (mEq./l)		Potassium (mEq./l)	
		Serum	Saliva	Serum	Saliva
1	Before Breakfast	140.50	19.50	5.00	21.13
	Before Lunch	140.50	5.25	5.10	20.50
2	Before Breakfast	140.50	24.50	5.00	21.25
	Before Lunch	140.50	5.50	5.00	18.12

much more variable than the serum Na and K concentration (3, 14, 24; table 5).

Recent evidence pointed to the important role played by the adrenal cortex in maintaining this selectivity. Thus, ACTH administration has been shown to decrease the salivary Na/K in normal subjects (2, 7, 8, 10, 23, 25) but not in patients with Addison's disease (7). Desoxycorticosterone has been shown to decrease the salivary Na/K of normal subjects (7) and in patients with Addison's disease (6). Finally, the Na/K of the saliva was higher in patients with Addison's disease and lower in patients with Cushing's disease than in normal subjects (7). Hence, where there was decreased adrenal cortical function, the salivary Na/K tends to be higher than where there was increased function of this gland. From the nature of the diurnal variation in the salivary Na/K it follows that the salt-regulating function of adrenal cortex should be at a low point before breakfast, reach a high point before lunch, and decline gradually toward evening. Other workers have demonstrated a similar daily rhythm in adrenal cortical activity as measured by the urinary excretion of the 17-ketosteroids and the neutral reducing lipids (17) and by the level of the eosinophilic polymorphoneuclear leukocytes of the blood (13, 18).

Influence of Age.—Men from 40 to 92 years of age had a significantly higher Na concentration in the saliva than men under 40 (table 5). On the other hand, the salivary Na concentration of women 40 years and older was not statistically different from that of women under 40 (table 5).

Men, and to a greater extent, women tended to have a significantly higher salivary K concentration when 40 years old or over than persons of the same sex younger than 40 (table 5).

There was no significant age difference in the salivary Na/K between subjects 5 to 39 years of age and those between 40 and 99, although there was a tendency for the salivary Na/K to be higher in men from 40 to 92 years old than in younger subjects, and the average reverse to be true in women (table 5).

In the light of the relationship between the level of the salivary Na/K and adrenal cortical function, this finding suggested that there was no clear-cut change in the salt-regulating function of the adrenal cortex during aging. This was in agreement with studies on the changes in adrenal cortical function during aging by other workers who showed that there was no significant change with age either in the excretion of neutral reducing lipids (16) or in the eosinopenic response to acute or chronic treatment with ACTH (11, 20, 21, 22). On the other hand, other investigators have shown that the daily urinary excretion of 17-ketosteroids was decreased in aging women (15). However, it is conceivable that the salt and sugar-active functions of the adrenal cortex may be maintained longer during aging even as the androgenic function declines.

Influence of Sex.—No statistical difference due to sex existed in the salivary Na in persons younger than 40, but in subjects 40 years and older, men had a significantly higher Na concentration than women of comparable age (table 5).

There was no sex difference in the K concentration of the saliva of persons younger than 40 or in that of older subjects (table 5).

Men from 40 to 92 years of age had a significantly higher salivary Na/K than women of the same age, but there was no statistically significant sex difference in the salivary Na/K in persons younger than 40 (table 5).

Because the salivary Na/K tended to increase in men after 40 and to decrease in women after 40, and even though each change by itself was not significant, their change in opposite directions was sufficient to create a significant sex difference in persons past 40. This suggests that women in later life have a higher level of adrenal cortical function than men of the same age. There are no reports in the literature on the relative level of adrenal cortical function in men and women and discussion on this subject must await further investigation in this field.

Summary

The Na and K concentration of human mixed unstimulated saliva was determined by direct intensity flame photometry in 52 men and 56 women from 5 to 99 years of age. Collections were made from each subject before each meal and at bedtime. The arithmetic mean and standard error of the salivary electrolyte concentration of all the specimens of 101 subjects who provided a complete set of 4 specimens was 11.62 ±0.42 mEq./l in the case of the Na, and 24.98 ± 0.46 mEq./l in the K. The mean Na/K was 0.46 ±0.02.

There was a definite diurnal variation in the salivary Na/K, the highest values occurring before breakfast, the lowest values before lunch or before supper, with a tendency for the values to rise at the end of the day. The diurnal variation was observed mostly in the Na concentration.

The salivary Na concentration of men from 40 to 92 years old was significantly higher than that of men younger than 40, but there was no significant difference in the Na concentration of the saliva of women in these 2 age groups. The salivary K concentration was significantly higher in both men and women from the 5th to the 9th decade as compared with that of younger subjects of the same sex. There was no significant difference in the salivary Na/K in persons from 40 to 99 as compared with those younger than 40.

The only significant difference due to sex in the salivary Na concentration and in the Na/K occurred in persons 40 years old and

older, the men having significantly higher values. There was no significant difference due to sex in the K concentration.

Because of the inverse relationship between the values of the salivary Na/K on the one hand and the degree of activation of the adrenal cortex on the other, the above data provided information about the alteration in the function of this gland due to diurnal variation, age, and sex.

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EXPERIMENTAL ARTERIOSCLEROSIS: EFFECT OF REPEATED INTRAVENOUS INJECTIONS OF EPINEPHRINE ON LIPID PARTITION OF PLASMA AND LIVER AND AORTIC DEGENERATIVE CHANGES IN INTACT RABBITS[1]

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A DISORDERED lipid metabolism is credited with being a significant factor in the pathogenesis of some types of arteriosclerosis (16). However, the nature of the disordered lipid metabolism and the factors responsible for the production of normal and abnormal plasma lipid relationships are practically unknown. The main lines of investigation of this problem at the present time are the influence of lipid-metabolic factors in the genesis of atherosclerosis and the role of degenerative phenomena of the medial coat in determining the location of atherosclerotic plaques.

An increased incidence and severity of medial arteriosclerosis in rabbits was reported by Josue (10) following repeated injections of epinephrine. These observations have been confirmed by other investigators (2, 6, 12). Particularly noteworthy is the report of Anitschkow (1) on the effects of combined administration of epinephrine and cholesterol to rabbits. It was found that under such circumstances atherosclerotic changes were superimposed on the epinephrine-induced arteriosclerotic lesions. Recently, Waters and de Suto-Nagy (21) showed that epinephrine and other substances induced injury to the arterial wall upon which atheromatous plaques were superimposed by utilizing agents which altered lipid transport in the blood.

It is generally agreed that certain endocrine products exert considerable regulatory influences upon lipid metabolism (4, 5, 9, 13). In view of the well-known interrelationships which exist between effects of epinephrine and insulin, anterior pituitary and adrenocortical hormones, it seemed desirable to determine the effect on rabbits of repeated intravenous injections of epinephrine on the lipid constituents of plasma and liver and to observe concurrently the extent and severity of degenerative changes in the aorta of these animals.

MATERIAL AND METHODS

The experiments were conducted on 2 groups of New Zealand white female rabbits. Prior to and during the experiment the rabbits were given a commercial feed (Hulburt's Rabbit Pellets without any antibiotics incorporated) and tap water ad libitum.

Group I comprised 48 animals which were received in lots of 8 20, and 20 within a period of sixty days. The animals at the onset of the experiment weighed between 2 and 2.5 Kg. Twenty-four[3] of the rabbits were injected with epinephrine, whereas 24 animals served as controls. The epinephrine administrations were given as a single daily intravenous injection of a 1:1000 aqueous solution of Adrenaline (Parke, Davis and Co.); the dose of adrenaline during the first five days valued 0.025 mg./Kg. body weight, and 0.050 mg./Kg. on the succeeding nine days. The control rabbits were given intravenous injections of a comparable quantity of sterile physiologic saline solution.

Group II consisted of 20 female white rabbits weighing between 1.5 and 2.0 Kg.

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[1] A preliminary report of this paper was presented at the XIX International Physiological Congress, Montreal, Canada, Aug. 31-Sept. 4, 1953.

[2] With the technical assistance of Frank Szematowicz. The authors also wish to acknowledge the assistance of Janice Stoneking and Muriel Dury.

[3] A total of 24 rabbits were injected with epinephrine. However, the data on only 19 are reported here since autopsy was performed on 1 rabbit of the first lot, 2 of the second, and 1 of the third at the end of seven days of epinephrine injection: and 1 rabbit of the third lot died a few minutes after epinephrine injection on the sixth day.

Ten[1] of the animals were subjected to epinephrine injections, whereas the remaining 10 rabbits were injected with saline and served as controls. The epinephrine dose during the first five days of the experiment was the same as for Group I, consisting of a single daily injection of 0.025 mg./Kg. During the succeeding nine days, however, the daily dose of epinephrine given was twice that administered to Group I, an injection of 0.050 mg./Kg. being given both during the morning and the afternoon.

The rabbits in both groups were sacrificed on the morning of the fifteenth day after the injections were initiated. The animals were anesthetized with an intravenous injection of Evipal (n-methyl-cyclohexenylmethyl barbituric acid). Thirty to 40 ml. of cardiac blood was obtained in a syringe moistened with a heparin solution. The blood was immediately centrifuged and the plasma obtained was used for the determination of plasma lipids and glucose (11). Immediately after securing the cardiac blood, the abdomen was opened and a lobe of liver removed. A section of this lobe was taken for the determination of liver glycogen (8, 18) content. The remainder of the liver lobe and an adequate aliquot of the plasma were utilized for lipid determination, using the procedure previously described (4).

The lipids were extracted with hot alcohol-ether, the solvent distilled off under partial vacuum and the residue redissolved in petroleum ether. Total lipids were calculated from the weight of the residue after distillation of the petroleum ether and drying to constant weight. Lipid phosphorus was determined by a modification of Youngsburg's (22) and Fiske and SubbaRow's methods (7). Phospholipid values were expressed as lipid phosphorus X 26. Total and esterified cholesterol were determined by the method of Schoenheimer and Sperry (15), whereas neutral fat was calculated by subtraction of free cholesterol, cholesterol oleate, and phospholipid concentrations from the total fat values.

The heart, the aorta, and specimens of other organs (kidneys, liver, pancreas, lungs, spleen, and adrenal gland) were removed from the rabbits for gross and microscopic examination by one of the authors (L.D.M.). Specimens of the latter organs were taken for the specific purpose of examining the condition of their blood vessels. In no instance were any signs of degenerative changes observed in the blood vessels of those organs. The tissues were fixed in 15 per cent formalin, dehydrated, and imbedded in tissue-mat (Fisher's). Sections of 6 μ thickness were cut and stained with Harris' hematoxylin and alcoholic eosin solutions. In all cases duplicate slides were also stained by Weigert elastica-van Gieson method. Some sections, when indicated, were stained for calcium by the method of von Kossa (20). Final grading of aortic degenerative condition was based on the microscopic findings in the serial sections of the ascending aorta. The grading of the lesions was done without knowledge of the treatment of the rabbits. The observations were restricted to the media since there were hardly any changes in the intima. The lesions designated as grade 1 (fig. 1, R-32) showed swelling of the ground substance between elastic fibers with or without slight fibroblastic infiltration; grade 2 (fig. 1, R-65)—swelling of the interfibrillary ground substance associated with fibroblastic proliferation and fragmentation of some elastic fibers; grade 3 (fig. 2, R-13)—fragmentation and necrosis of some elastic fibers together with fibroblastic proliferation, calcification being frequently present in necrotic areas; grade 4 (fig. 2, R-"A")—the same as grade 3 except for more extensive changes.

RESULTS

Group I: Biochemical Observations. The results of the liver and plasma analyses for Group I are summarized in table 1. Since the results were obtained from analyses of tissue samples from 3 separate lots of rabbits, the data were tested by the procedures of

[1] Two rabbits died on the 12th day and one each on the 13th and 14th day of the experiment within a few minutes after epinephrine injection.

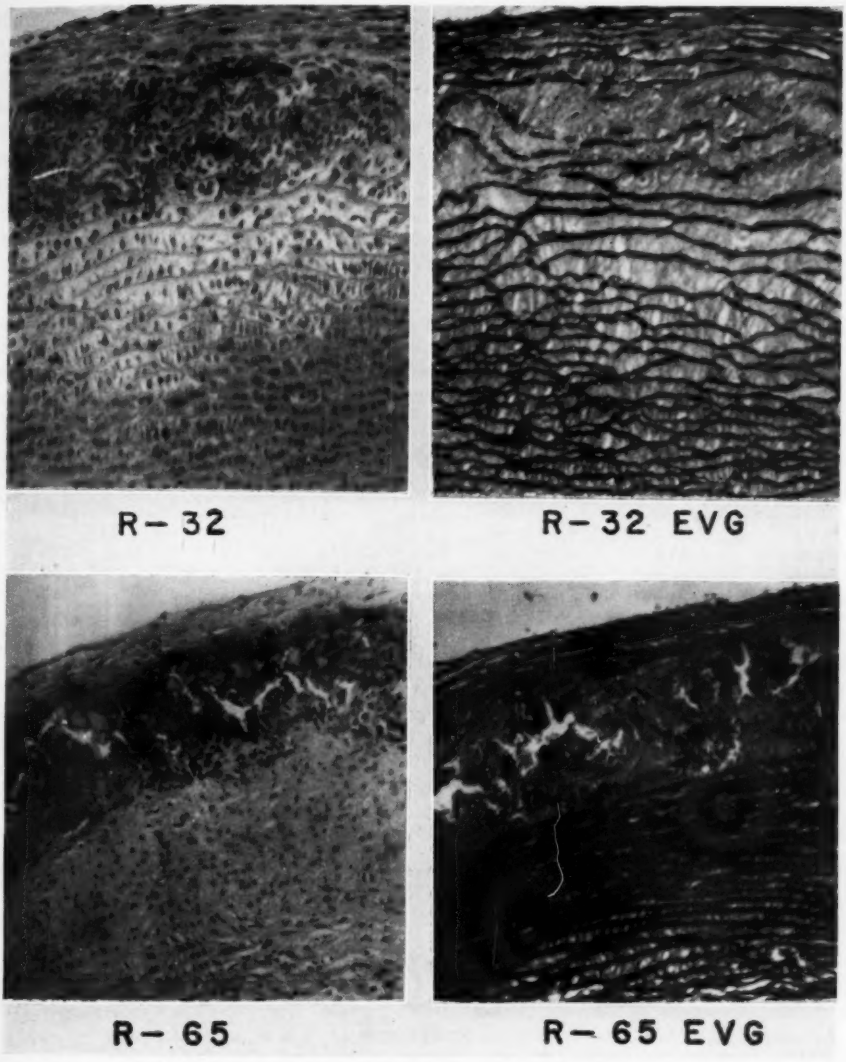

FIG. 1. Photomicrographs of Hematoxylin-Eosin and Weigert Elastica-Van Gieson stained sections of aorta from epinephrine-injected or control rabbits. See text for discussion of these figures.

analyses of variance (17) in order to obtain adequate statistical evaluation of the influence of the two major factors which might affect the outcome of the experiment. These were the factor of *time* as affecting the results between groups treated similarly but derived from different shipments and the factor of *treatment* as affecting the results between groups treated differently, i.e., saline-injected or epinephrine-injected.

As seen from table 1 no difference in the mean concentrations of total lipids, of various

lipid fractions, and of glycogen in the liver was observed between the epinephrine injected rabbits and the controls either as a result of treatment or time. The mean plasma total lipid content was probably significantly lower ($P = 0.05$) in the experimental rabbits than in the controls as a result of the difference in treatment. Except for the difference in the plasma neutral fat content determined to be the effect of the factor time there was no difference between the mean values of any other plasma constituents in the control and experimental groups.

Since the relationship of certain plasma lipid fractions is believed to reflect more discretely alterations in lipid metabolism than absolute values, the ratios of certain lipid and cholesterol fractions were calculated from the original data. These ratios are presented in table 2. By pro-

TABLE 1. CHANGES IN LIVER AND PLASMA CONSTITUENTS IN INTACT RABBITS FOLLOWING EXTENDED EXHIBITION OF EPINEPHRINE INTRAVENOUSLY[1]

	Total Lipids	Phospho-lipids	Cholesterol Total	Cholesterol Free	Cholesterol Ester	Neutral fat	Glycogen
	Part A. Liver Lipids Partition and Glycogen (Gm.%)[2].						
Controls (24)	4.84 ± .15	4.04 ± .45	.21 ± .005	.19 ± .004	.02 ± .001	.59 ± .11	3.2 ± .2
Epinephrine (19)	4.81 ± .12	4.10 ± .55	.21 ± .006	.19 ± .006	.03 ± .004	.56 ± .09	3.8 ± .4
	Part B. Plasma Lipids Partition and Glucose (Mg.%)						Glucose
Controls (24)	460.4 ± 20.5	116.5 ± 6.7	54.8 ± 3.1	24.2 ± 1.4	30.6 ± 1.9	266.2 ± 17.2	96 ± 3
Epinephrine (19)	403.2 ± 21.1	105.1 ± 4.3	55.8 ± 3.1	25.0 ± 1.1	30.8 ± 2.2	211.2 ± 15.3	105 ± 3
Probability of "F"[3] Ratio Values for Treatment (T) and Lots Treated Alike (L) Occurring by Chance. "F" Values Were Derived from Procedures of Analysis of Variance. Only Significant "P" Values Are Given.							
"P" (T) =		0.05					
"P" (L) =						0.03	

All partition values are Mean ± S. E.
[1] Epinephrine administered intravenously in single daily injections for 14 days; saline given to controls. See text for dose schedule.
[2] No significant differences were found in the liver partition values due to treatment or time (lots treated alike); therefore no "P" values are given.
[3] "F" obtained from Analysis of Variance procedures is the ratio of the mean square for treatment to the mean square for error, similarly for lots treated alike (time factor).

TABLE 2. RELATIONSHIPS OF CERTAIN PLASMA LIPIDS. (RATIOS[1] DERIVED FROM QUANTITATIVE DATA OF TABLE 1)

	Free Cholesterol/ Total Cholesterol	Total Cholesterol/ Lipid-phosphorus	Phospho-lipid/ Free Cholesterol	Neutral Fat/ Phospho-lipid
Controls (24)	44.5 ± 1.0[1]	12.4 ± .53	4.92 ± .21	2.49 ± .18
Epinephrine (19)	45.7 ± 1.4	14.2 ± .57	4.18 ± .16	2.08 ± .16
Probability of "F"[2] Ratio Values for Treatment (T) and Lots Treated Alike (L) Occurring by Chance				
"P" (T) =		0.03	0.01	
"P" (L) =	0.01			0.01

[1] Ratio values are Mean ± S. E.
[2] See explanation to table 1.

cedures of the analyses of variance it was concluded that the difference in treatment was responsible for the significantly different mean values of the ratios total cholesterol: lipid-phosphorus and the phospho-lipid: free cholesterol. The mean values of the ratios free cholesterol: total cholesterol and neutral fat: phospho-lipid of the control and experimental rabbits were found to be *not* attributable to the types of treatment but the differences between the means due to the factor time as between animals treated alike.

Histologic Observations. The frequency and severity of degenerative conditions in the ascending aorta in the epinephrine injected rabbits and the controls are shown in table 3. No difference was found between the groups either in the percentage incidence of medial degenerative changes or with regard to structural character of the lesions. A calculation, however, of the severity factor index (percentage incidence × average degenerative change) shows that more severe medial degenerative conditions were found in the epinephrine injected rabbits than in the control animals.

Group II: Biochemical Observations. The results of the biochemical observations for the animals in Group II are summarized in tables 4, 5, and 6. The data in table 4

TABLE 3. SUMMARY OF AORTIC DEGENERATIVE CHANGES OBSERVED IN CONTROL AND EPINEPHRINE-INJECTED INTACT RABBITS. (MEASUREMENT DATA IN TABLE 1.)

	Grades and Frequency of Aortic Degenerative Changes Observed					Percentage Incidence[1]	Average Degenerative Change	Severity Factor[2]
	0	1	2	3	4			
Controls (24)	12	7	4	1	0	50	0.75	37.50
Epinephrine (20)	7	6	4	3	0	65	1.15	74.75

[1] The Difference in percent incidence (of degenerative changes) between the 2 groups was *not* statistically significant by the method of Chi-Square.
[2] Severity factor = % Incidence X Average Degenerative Change

TABLE 4. CHANGES IN LIVER AND PLASMA CONSTITUENTS IN INTACT RABBITS FOLLOWING EXTENDED EXHIBITION OF MULTIPLE DAILY INJECTIONS OF EPINEPHRINE[1]

	Total Lipids	Phospho-lipids	Cholesterol Total	Cholesterol Free	Cholesterol Ester	Neutral Fat	Glycogen
Part A. Liver Lipids Partition and Glycogen (Gm%).[2]							
Controls (10)	4.44 ± .18	3.84 ± .15	.21 ± .008	.19 ± .007	.02 ± .003	.37 ± .06	5.4 ± .5
Epinephrine (6)	4.40 ± .16	3.90 ± .17	.21 ± .006	.19 ± .006	.02 ± .003	.27 ± .05	5.3 ± .4
Part B. Plasma Lipids Partition and Glucose (Mg.%).							Glucose
Controls (9)	276.9 ± 11.5	79.9 ± 4.6	55.4 ± 2.6	19.3 ± 1.5	36.0 ± 1.6	114.0 ± 6.0	109 ± 3
Epinephrine (6)	358.4 ± 20.6	94.6 ± 2.5	53.6 ± 4.5	23.6 ± 2.1	29.9 ± 3.1	178.3 ± 12.1	103 ± 4
Probability of Difference Between Means Occurring by Chance[3]							
"P" =	0.003	0.03				0.003	

All partition values are Mean ± S. E.
[1] Epinephrine injected intravenously. A single daily injection for 5 days, then twice daily for succeeding 9 days. See text for dose schedule.
[2] The partition values of the liver constituents in the epinephrine group were found not significantly different from the respective control values; therefore no "P" values are given.
[3] Only significant "P" values are given.

TABLE 5. RELATIONSHIPS OF CERTAIN PLASMA LIPIDS. (RATIOS[1] DERIVED FROM QUANTITATIVE DATA OF TABLE 4.)

	Free Cholesterol/ Total Cholesterol	Total Cholesterol/ Lipid-phosphorus	Phospho-lipid/ Free Cholesterol	Neutral Fat/ Phospho-lipid
Controls (9)	34.6 ± 1.7	18.6 ± 1.2	4.2 ± .5	1.45 ± .09
Epinephrine (6)	44.4 ± 2.7	14.6 ± 1.0	4.1 ± .3	1.89 ± .17
Probability of Difference Between Means Occurring by Chance[2]				
"P" =	0.008	0.04		0.025

[1] Ratio values are Mean ± S. E.
[2] Only significant "P" values are given.

TABLE 6. SUMMARY OF AORTIC DEGENERATIVE CHANGES OBSERVED IN CONTROL AND EPINEPHRINE INJECTED INTACT RABBITS. (MEASUREMENT DATA IN TABLE 4.)

	Grades and Frequency of Aortic Degenerative Changes Observed					Percentage Incidence	Average Degenerative Change	Severity Factor[1]
	0	1	2	3	4			
Controls (10)	5	2	0	3	0	50	1.10	55.00
Epinephrine (10)	1	4	1	3	1	90[2]	1.90	171.00

[1] Severity factor = % incidence X Average Degenerative Change.
[2] The critical ratio of the percentage incidence (of degenerative changes) in both groups compared by the method of Chi-Square was *significant at less than 5% level.*

show that similarly to the results obtained in Group I there was no difference between the control and experimental rabbits in the lipid and glycogen content of the liver. However, the mean plasma concentrations of total lipids, phospho-lipids, and neutral fat were significantly greater in the epinephrine injected rabbits than in the control group.

The relationship of certain plasma lipid and cholesterol fractions derived from the absolute plasma values are summarized in table 5. In the epinephrine injected rabbits the ratios free cholesterol: total cholesterol and neutral fat: phospho-lipids were significantly greater, and the mean ratio total cholesterol: lipid-phosphorus was significantly lower than in the control group.

Histologic Observations. The incidence and severity of the aortic degenerative changes found in the control and epinephrine injected rabbits of this experiment are shown in table 6. The difference in percentage incidence of aortic degenerative changes which were observed in the 2 groups of animals was significant at the probability level of less than 5 per cent of occurring by chance alone. In terms of the severity factor the degenerative changes in the medial coat observed in the epinephrine injected rabbits were 3 times greater than observed in the control group.

It should further be pointed out that several of the epinephrine injected animals in Group II displayed changes in the aorta which were not observed in the controls or in the epinephrine injected rabbits of Group I. These changes consisted of a very acute type of media necrosis as evidenced by an almost complete lack of staining with hematoxylin (fig. 2, R- "B"). Because of the apparent rapidity with which these changes developed there was only minimal cellular reaction; in one instance there was an acute hemorrhage and beginning dissection of the necrotic media (fig. 2, R- "B").

DISCUSSION

Previous studies concerning the effect of epinephrine on lipid metabolism are very scanty. Cori and Cori (3) deduced from their data that fat was the material used for the increased metabolism due to epinephrine. An

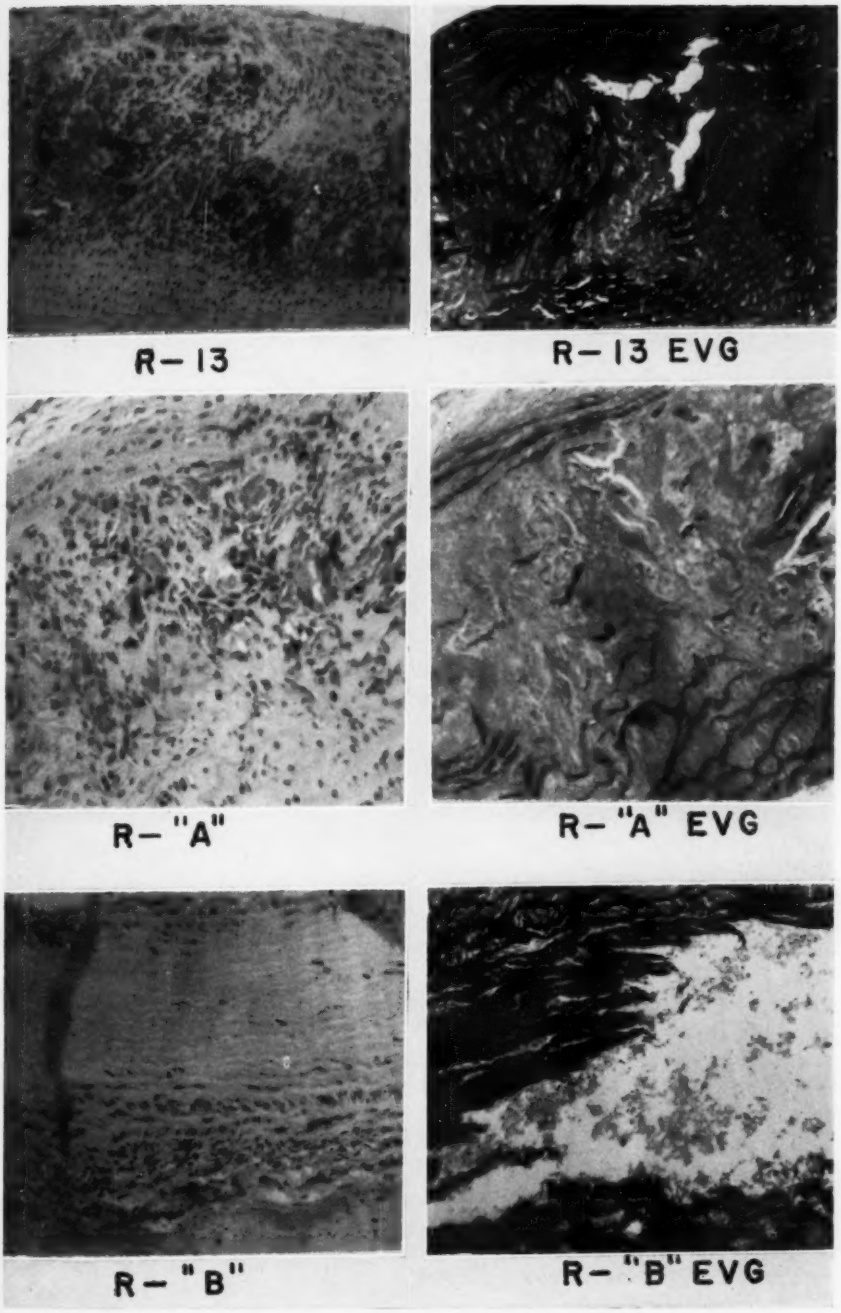

FIG. 2. Photomicrographs of Hematoxylin-Eosin and Weigert Elastica-Van Gieson stained sections of aorta from epinephrine-injected rabbits. See text for discussion of these figures.

increase in liver phospho-lipids and fatty acids occurring two to three hours after subcutaneous injection of epinephrine in rabbits has been reported by Pollack (14). Dury and Treadwell (4) observed an increase in liver neutral fat and decrease in phospho-lipid content sixty minutes after subcutaneous injection of epinephrine in rats. In the studies presented here the liver content of total lipids or lipid fractions of the rabbits injected daily with single or multiple doses of epinephrine were not different from respective control values. These results may not be accepted as conclusive evidence of the absence of an epinephrine effect on liver lipid metabolism. The quantitative content of any liver lipid fraction is obviously at any moment of time the resultant of such processes as mobilization to and removal from the liver, of synthesis, and oxidation. It is believed that the changes in content of plasma lipid fractions together with the altered plasma lipid relationships found in the epinephrine treated rabbits should be emphasized as indicative of an epinephrine effect on lipid-metabolic relationships rather than the lack of evidence of quantitative changes in liver lipids partition.

The importance of certain plasma lipid relationships on the genesis of atherosclerosis has received considerable emphasis in recent years. It is generally conceded that a lipaemic-appearing plasma is seen when lipid relationships are altered so that the total cholesterol to phospho-lipids ratio is *decreased* and the ratio free cholesterol to total cholesterol is *increased*. Exactly these changes in the plasma lipid relationships and an increased neutral fat: phospho-lipid ratio were found in the rabbits given daily multiple injections of epinephrine (table 5). Notably, only in these treated rabbits was the plasma lipaemic. Stamler and associates (19) attributed the lipaemic appearance of the plasma and the increased incidence of atheromatous lesions in the thoracic aorta to such changes found in the plasma lipid pattern of cockerels following implantation of diethylstilbesterol.

The mechanisms whereby epinephrine tends to induce changes in plasma lipids relationships are open to speculation. They may reflect a direct effect of epinephrine on certain phases of lipid metabolism or indirectly the influence of the hormone on carbohydrate metabolism, or the metabolic consequences of some complex interrelationships which involve epinephrine-anterior pituitary-adrenocortical functions. Since it is generally conceded that epinephrine is a notable factor in producing injury to the medial wall, the evidence presented here showing an effect of epinephrine on plasma lipid-metabolic relationships is suggestive of a more significant role of epinephrine or other endocrine factor(s) in the problem of the pathogenesis of arteriosclerosis than has been indicated in previous experience.

SUMMARY

Injection of epinephrine to rabbits over a fourteen day period produced no changes in lipid or glycogen content of the liver but was followed by certain changes in plasma lipid ratios and by degenerative lesions in the aortic media. The histologic changes were most pronounced in animals subjected to epinephrine injections twice daily during the last nine days of the experiment. The mechanism of the epinephrine action is discussed.

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AGE CHANGES IN MENTAL ORGANIZATION— A LONGITUDINAL STUDY[1]

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THE problem of the organization of mental abilities has been approached factorially by a number of investigators. However, the further problem of the evolution of this organization over the life span has received much less attention. Garrett (4) has indicated that from childhood through college age there seems to be a decrease in "G" and an increase in the prominence of more specialized abilities. Whereas Balinsky (1), employing Wechsler's normative data, obtained a comparable result over the same age span, he observed in addition that there seemed to be a return to an increased prominence of "G" in late adulthood (ages 50-59).

With respect to the latter result, it seems that all evidence currently available has been derived from cross-sectional studies. It is the thesis of the authors that a longitudinal investigation of the evolution of mental organization from early to late maturity is indicated in the interest of obviating certain methodologic problems. For example, if differences between age groups are to be fairly attributed to differences in underlying mental organization, then clearly it is true that the training of the groups must be comparable. This is, of course, not the case in the comparison of 20 to 29 year olds with 50 to 59 year olds. By and large, the former have had not only more training, but more specialized training as well. Cross-sectional results are thus biased in the direction of finding exactly what has been found, and a new approach seems indicated. Accordingly, the present paper is concerned with a factorial study of some longitudinal evidence as to age changes in mental organization occurring between the mean ages of 19 years and 50 years. The factorial technique employed was the Hotelling principal axis method, and the data were those obtained in a longitudinal investigation reported in detail elsewhere (6).

This study has 3 purposes: 1) To factor twice the results of the Army Alpha, as administered to a specified group of *Ss* in 1919, and as readministered to these same individuals in 1950; 2) To apply Bartlett's test of significance (2, 3) of the successive latent roots in order to determine approximately how many factors can be regarded as statistically significant in each analysis (to the knowledge of the authors this is one of the first applications of this test which makes it possible to eliminate the weakest feature of current factorial methods); 3) To compare the results of the 1919 and 1950 analyses for any possible interpretations relative to age changes in mental organization.

MATERIAL AND METHODS

Of the 8 subtests of Alpha, 7 were used in the analysis: 1) Arithmetic, 2) Common Sense, 3) Synonym-antonym, 4) Disarranged Sentences, 5) Number Series Completion, 6) Analogies, and 7) Information. The first subtest, Following Directions, was omitted because of its recognized unreliability. The sample involved consists of 127 subjects who took the indicated examination at Iowa State in 1918-1919 as an entrance test, and who were relatively homogeneous as to sex, age, and educational status. The 1919 correlation matrix, with entries corrected for atten-

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[1] This research was done under contract number N7ONR-37103 between the Office of Naval Research and Iowa State College; however, the opinions and assertions contained herein are those of the writers and are *not* to be construed as official or reflecting the views of the Navy Department or the naval service at large.

uation[1], is given in table 1. (The 1950 matrix appears in context in table 5.)

TABLE 1. 1919 CORRELATION MATRIX FOR 7 SUBTESTS OF THE ARMY ALPHA, IOWA STATE COLLEGE SAMPLE

Subtest	1	2	3	4	5	6	7
1. Arithmetic	1.00	.49	.40	.34	.69	.58	.26
2. Common Sense		1.00	.56	.48	.37	.41	.58
3. Synonym-Antonym			1.00	.56	.39	.30	.61
4. Disarranged Sentences				1.00	.35	.43	.62
5. Number Series Completion					1.00	.55	.27
6. Analogies						1.00	.24
7. Information							1.00

Entries rounded to two places.

RESULTS

The principal component analysis[2] of this matrix is summarized in table 2, which gives the factor loadings for each test, i.e., the square root of the proportions of their variances associated with 7 orthogonal components or factors which will account for the observed intercorrelations. It is indicated then, that the first principal component "explains" about 54 per cent, i.e., 100 (.734979)^2 per cent of the variance on the Arithmetic test, about 59 per cent of that on the Common Sense test, about 57 per cent on the Synonym-Antonym test, about 55 per cent on the Disarranged Sentences test, about 50 per cent on the Number Series Completion test, about 46 per cent on the Analogies test, and about 50 per cent on the Information test.

Similarly, the amount of test variance accounted for by the other principal components can be determined from table 2. Clearly, so far as practical significance is concerned, the first 2 principal components remove a very large proportion of the total variance. However, the question now arises as to the statistical significance of these various factors. By far the best procedure for this problem is the χ^2 approximation criterion recently developed by Bartlett (2, 3). It is, of course, true that this test of significance is probably affected to some extent by the fact that the correlations have been corrected for attenuation. In the present instance this is ignored. The test statistic is

$$\chi^2 = -\left[n - \frac{1}{6}(2p + 5) - \frac{2}{3}k\right] \log_e R_{p\text{-}k}$$

with $\frac{1}{2}(p-k-1)(p-k+2)$ degrees of freedom,

[1] The correction was applied because the intercorrelations would otherwise seem to be substantially conditioned by relatively low and heterogeneous subtest reliabilities.

[2] Hotelling's computational methods (5) were used; the actual calculations were made in the statistical laboratory, Iowa State College.

TABLE 2. 1919 FACTOR LOADINGS FOR ARMY ALPHA SUBTESTS BY THE METHOD OF PRINCIPAL AXES

Subtest \ Factor	I	II	III	IV	V	VI	VII
1. Arithmetic	.73	−.50	−.23	.01	−.06	.22	.32
2. Common Sense	.77	.19	−.29	.48	−.03	.09	.22
3. Synonym-Antonym	.76	.34	−.21	−.28	.44	−.03	.00
4. Disarranged Sentences	.74	.32	.47	−.13	−.09	.32	.06
5. Number Series Completion	.71	−.50	−.11	−.33	−.21	−.12	.26
6. Analogies	.68	−.45	.42	.26	.21	−.23	.04
7. Information	.70	.55	−.01	−.01	−.28	−.29	.20
Latent Roots, i.e., Factor Variances (Sum of Squares), λ_i, i = 1, 2, ··· 7	3.71	1.26	.58	.50	.37	.31	.26
Percent of total variance	53.0	18.0	8.3	7.2	5.2	4.5	3.8

for testing the significance of the total residual correlation left after k factors have been extracted, and for testing that of each factor separately after all have been extracted. In this expression, n=the total number of degrees of freedom available from the original observations, viz., n=N − 1 where N=the sample size, 127 here; p=the number of factors or roots, and k=the number of factors that have been extracted. Thus the coefficient of $\log_e R_{p-k}$ becomes here

$$-\left[126 - \frac{1}{6}[(2)(7)+5] - \frac{2}{3}k\right] = -[122.83333 - \frac{2}{3}k]$$

Finally, R_{p-k} is defined by the relation

$$R_{p-k} \frac{\lambda_1 \cdot \lambda_2 \ldots \lambda_p}{\lambda_1 \lambda_2 \ldots \lambda_k \left[\frac{p - \lambda_1 - \lambda_2 - \ldots - \lambda_k}{p-k}\right]^{p-k}}$$

Bartlett's test statistic, applied to the latent roots of table 2, where n=127 − 1=126, and p=7, yields the Chi-square analysis shown in table 3. Naturally, no significance can be attached to the last root. To quote Bartlett (2, p. 80) to test λ_7 ". . . . would be equivalent to asking for the correlation structure of a single test, since in the test of significance what is being investigated is . . . the correlation structure of the tests in its relation to variance." Note that the statistical significance of the entire correlation structure is under test for k=0. In this case, it is highly significant (χ^2=391.2). The remaining values of k correspond to the situation more usually of interest, of testing the significance of the roots remaining after having removed the largest k roots. Thus we see that the total residual correlation left after the first factor has been extracted is highly significant (χ^2=108.8). The remaining correlation structure is also significant at the 5 per cent level after the first and second factors have been removed (χ^2=26.6) and also after the first, second, and third principal components have been removed (χ^2=14.3), but not after the first, second, third, and fourth have been extracted (χ^2=3.3). The first 4 factors are significant at the 5 per cent level, but the others do not reach significance.

In place of presenting the analysis as each set of residual factors is tested in turn for significance, the results may be indicated as in table 4, where the method used is that of testing the significance of each factor separately after all have been extracted. This second set of χ^2 and d.f. values are obtained from the first set by consecutive subtraction. From either table, it is apparent that the hypothesis of homogeneity of the last 3 roots is not disproved.

In view of the above results and of the loadings of table 2, a possible psychologic interpretation of the first 4 factors for the 1919 data is as follows: The chief component, I_{1919}, which accounts for a total of 53 per cent of the variance, seems to be closely related to general ability, since it has approxi-

TABLE 3. CHI SQUARE ANALYSIS OF THE TOTAL AND PART CORRELATION STRUCTURE, 1919

k	Latent Roots, λ_i, Present							d.f.	R_{7-k}	χ^2 [1]	χ^2 at the 5% Level for the Specified d.f.
0	λ_1	λ_2	λ_3	λ_4	λ_5	λ_6	λ_7	21	.041399	391.2	32.7
1		λ_2	λ_3	λ_4	λ_5	λ_6	λ_7	15	.410381	108.8	25.0
2			λ_3	λ_4	λ_5	λ_6	λ_7	10	.803596	26.6	18.3
3				λ_4	λ_5	λ_6	λ_7	6	.888392	14.3	12.6
4					λ_5	λ_6	λ_7	3	.972817	3.3	7.8
5						λ_6	λ_7	1	.992731	0.9	3.8
6							λ_7	0	1.000000	0.0	—

[1] $\chi^2 = -[(122.8333 - 2/3\ k) \log_e R_{7-k}]$

TABLE 4. CHI-SQUARE ANALYSIS OF SEPARATE FACTORS, 1919

Latent Root	d.f.	χ^2	χ^2 at 5% Level for the Specified d.f.
λ_1[1]	6	282.4	12.6
λ_2[1]	5	82.2	11.1
λ_3[1]	4	12.3	9.5
λ_4[1]	3	11.0	7.8
λ_5	2	2.4	6.0
λ_6	1	0.9	3.8

[1] Indicates significance at at least the 5% level.

nately the same rather high loadings for all tests, ranging in magnitude from 46 per cent (test 6, Analogies) to 59 per cent (test 2, Common Sense). The second factor II_{1919}'s accounting for 18 per cent of the variance, might be said to indicate a difference between memory for information on the one hand, and quantitative and/or reasoning ability on the other. This interpretation is based on the fact that II_{1919}'s highest loading is on subtest 7, Information (30.5 per cent of test 7), and II_{1919}'s next 3 highest loadings are all negative in sign, which is opposite in direction to test 7. These tests are test 5, Number Series Completion, (25 per cent); test 1, Arithmetic, (25 per cent); and test 6, Analogies, (20 per cent). With respect to III_{1919}; the third factor which accounts for slightly over 8 per cent of the variance, it might be interpreted as representing verbal manipulation, since III_{1919}'s highest loadings are on test 4, Disarranged Sentences (22 per cent), and test 6, Analogies (17 per cent). The rest is probably trivial for III_{1919}. Finally, the fourth component, IV_{1919}, accounting for a bit over 7 per cent of the variance, may be mainly identified with test 2, Common Sense (24 per cent). The remaining components are probably of neither statistical nor psychologic importance.

Turning now to the 1950 test results on the Alpha, for these same subjects but 31 years later, the matrix of test intercorrelations, corrected for attenuation, is given in table 5.

TABLE 5. 1950 CORRELATION MATRIX FOR 7 SUBTESTS OF THE ARMY ALPHA, IOWA STATE COLLEGE SAMPLE

Subtest	1	2	3	4	5	6	7
1. Arithmetic	1.00	.36	.52	.62	.83	.59	.42
2. Common Sense		1.00	.54	.55	.36	.55	.61
3. Synonym-Antonym			1.00	.74	.50	.66	.74
4. Disarranged Sentences				1.00	.56	.64	.60
5. Number Series Completion					1.00	.58	.45
6. Analogies						1.00	.57
7. Information							1.00

TABLE 6. 1950 FACTOR LOADINGS FOR ARMY ALPHA SUBTESTS BY THE METHOD OF PRINCIPAL AXES

Subtest \ Factor	I	II	III	IV	V	VI	VII
1. Arithmetic	.78	.54	.07	−.07	.07	.00	.30
2. Common Sense	.71	.44	.53	−.04	.13	.09	.00
3. Synonym-Antonym	.85	−.23	−.35	.02	.01	.32	.01
4. Disarranged Sentences	.85	−.04	−.17	.22	.37	−.19	.15
5. Number Series Completion	.77	.54	.10	−.20	−.05	.05	.25
6. Analogies	.83	.00	.07	.39	−.38	−.07	.00
7. Information	.79	−.38	−.16	−.38	−.17	−.21	.02
Latent Roots, i.e., Factor Variances (Sum of Squares), λ_i, i = 1, 2, ··· 7	4.44	.98	.48	.39	.34	.20	.17
Percent of total variance	63.4	14.0	6.8	5.6	4.9	2.8	2.5

TABLE 7. CHI SQUARE ANALYSIS OF THE TOTAL AND PART CORRELATION STRUCTURE, 1950

k	Latent Roots, λ_i, Present							d.f.	R_{7-k}	χ^2 [1]	χ^2 at the 5% Level for the Specified d.f.
0	λ_1	λ_2	λ_3	λ_4	λ_5	λ_6	λ_7	21	.009453	572.6	32.7
1		λ_2	λ_3	λ_4	λ_5	λ_6	λ_7	15	.353131	127.2	25.0
2			λ_3	λ_4	λ_5	λ_6	λ_7	10	.689469	45.2	18.3
3				λ_4	λ_5	λ_6	λ_7	6	.789513	28.6	12.6
4					λ_5	λ_6	λ_7	3	.877662	15.7	7.8
5						λ_6	λ_7	1	1.001644	−.2 [2]	3.8
6							λ_7	0	1.000000	0.0	—

[1] $\chi^2 = -[(122.8333 - 2/3\ k)\ \log_e R_{7-k}]$

[2] The value of χ^2 is essentially zero here, the discrepancy being due to rounding error.

The analysis into principal components of this retest data gave the results presented in table 6. Bartlett's test for the Significance of the Factors leads to table 7, from which it is seen that the total residual correlation left after the first 4 principal factors have been removed is significant at the 5 per cent level. An analysis for significance by factors yields table 8. Examination of either table 7 or 8

TABLE 8. CHI-SQUARE ANALYSIS OF SEPARATE FACTORS, 1950

Latent Root	d.f.	χ^2	χ^2 at 5% Level for the Specified d.f.
λ_1 [1]	6	445.4	12.6
λ_2 [1]	5	82.0	11.1
λ_3 [1]	4	16.6	9.5
λ_4 [1]	3	12.9	7.8
λ_5 [1]	2	15.9	6.0
λ_6	1	−.2 [2]	3.8

[1] Indicates significance at at least the 5% level.

[2] c.f. footnote to table 7.

leads to the conclusion that the first 5 components are of statistical significance at the level chosen. Though this result differs from the 1919 analysis in identifying one more component with statistical significance, yet a comparison of the percentage of total variance accounted for by each of the several factors in 1919 with that accounted for by them in 1950 leads one to doubt the practical significance of the fifth component in the 1950 data. It will be ignored in the following discussion.

The loadings of table 6, then, lead to the association of the first 4 factors with mental functions as follows: The chief component, I_{1950}, which accounts for a total of 63 per cent of the variance, seems to measure what can most directly be called general ability, because it has approximately the same loadings for all tests; these range in magnitude from 50 per cent (test 2, Common Sense) to 73 per cent (test 4, Disarranged Sentences). The second factor, II_{1950}, accounting for 14 per cent of the variance, may perhaps be said to measure primarily quantitative reasoning ability, since it has positive loadings of 30 per cent on test 5 (Number Series) and of 29 per cent on test 1 (Arithmetic). It could also be interpreted as representing a difference between quantitative ability on the one hand, and common sense plus information on the other, since it has negative loadings of 19.5 per cent on test 2 (Common Sense) and of 14 per cent on test 7 (Information).

Concerning III_{1950}, which accounts for about 7 per cent of the variance, an association with test 2, Common Sense, is probably reasonable, since the highest loading is on this test (28 per cent).

Finally, the fourth component, IV_{1950},

which "explains" a total of nearly 6 per cent of the variance, suggests that a difference between verbal reasoning and information is prominent in view of the loadings of about 16 per cent on test 6 and 14 per cent (negative) on test 7.

Discussion

A review of the foregoing suggests the following evaluation. As is customary in a principal component analysis of intellective tests, the primary factor in both 1919 and 1950 is essentially "G," or general ability. The effect of the specified age increment upon this factor was, apparently, to increase or broaden it, since it accounts for 10 per cent more of the total variance in 1950 than it did in 1919.

With respect to the second factor, it apparently can be at least partially identified with quantitative reasoning in both the 1919 and 1950 analyses, since both Arithmetic Reasoning and Number Series Completion are prominent in it on both occasions. It may, however, be fully as significant to observe that this factor is *more* highly correlated with Common Sense in the second of the 2 analyses, and *less* highly correlated with Analogies and Disarranged Sentences, both of which involve verbal manipulation and/or verbal reasoning.

In the case of the third factor, it seemed to be highly correlated with tests involving verbal manipulation and/or verbal reasoning in 1919 (Disarranged Sentences and Analogies); however, by 1950 it was not substantially correlated with either of these, and seemed to be closely related only to Common Sense. Such a change would seem to be a not unreasonable accompaniment of advancing age.

The changes in factor number 4 seem to be somewhat complementary to those which occured in number 3. IV_{1919} is highly correlated with Common Sense; whereas IV_{1950} seems to represent a difference between verbal reasoning (Analogies) and a more static form of verbal memory (Information).

Finally, a question arises as to the overall significance and meaning of these results. Clearly, they do affirm Balinsky's cross-sectional findings to the effect that "G" is more prominent in late than in early maturity. However, to the authors, the problem of the interpretation of this outcome is not a simple one. It seems to make good "psychobiologic sense" to assume, as suggested by Garrett (4), that mental abilities do show increasing differentiation from elementary school age to college age. Why this trend should be reversed in later maturity is the question. Two hypotheses suggest themselves. The first, which is somewhat artifactual, is that the mean intercorrelation of the subtests and the amount of "G" present were larger in 1950 because the mean variability was greater then than in 1919. The authors are inclined to minimize the importance of this effect for 3 reasons: 1) The difference between mean sigmas on total score was very small and barely tested significant at the 5 per cent level; 2) The pattern of increased or decreased variability, by subtests, was very inconsistant; and 3) The only highly significant changes in this pattern were on 2 subtests, where they seemed to be equal in magnitude, but opposite in direction.

The second and more fundamental hypothesis is that the mean intercorrelation of the subtests and the amount of "G" increased from 1919 to 1950, because the 30-year period between had the effect of permitting some equalization of exposure to and experience with the several test-function areas. It would surely seem to be a not unlikely assumption that the subjects of this investigation, as college freshmen, had not had such equal experience or exposure. They varied widely, for example, with respect to urban versus rural background, size of high school attended, and related variables. If this first assumption be granted, it may be argued that a common type of college education subsequent to the initial testing would tend to produce greater equality. The quarter-century or so which followed may have been, then, simply a time during which all subjects fortuitously experienced an increased num-

ber of exposures to somewhat test-related content. Obviously, the larger the number of such exposures, the less significant initial inequalities, until, with infinite exposure, they would lose all significance. This is apparently a tedious way of suggesting that it is more probable that each individual was measured at approximately the same point on his 8 subtest-function learning curves, i.e., near the top, in 1950 than in 1919.

It is still, of course, entirely possible that the observed changes in mental organization are primarily maturational in character and conditioned upon the operation of factors unidentified here.

Summary

The Army Alpha Examination, Form 6, was administered to 127 male freshmen at Iowa State College during 1918-1919 and readministered to this same group after an interval of 31 years during 1949-1950. Each matrix of sub-test intercorrelations was factored by the method of principal components and the two solutions were compared. It is apparent that there was a larger amount of "G" present in the test results of the present subjects at mean age 50 (1950) than at mean age 19 (1919).

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DIFFERENTIAL EFFECTS OF AGE UPON INTELLECTUAL FUNCTIONS DIFFERING IN DEGREE OF GENETIC CONDITIONING[1]

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THE purpose of this investigation was to determine whether several intellectual functions, classified by degree of parent-child resemblance, are differentially affected by a 30-year age increment.

METHOD

The present study represents one aspect of a larger, longitudinal investigation of the effects of age upon mental abilities (1). In connection with the latter, 127 men of mean age 19 who had taken Army Alpha, Form 6, as freshmen at Iowa State College during early 1919 were retested during 1950. Test and retest scores were recorded as normalized standard scores from norm distributions for 1,000 comparable cases. Thus, it was possible to observe differential 30-year increments in the 8 subtest functions of Alpha in comparable form by subtracting the 1919 scores from the 1950; it may be noted that the resulting difference, "D," scores were of necessity reported in units of the norm sigma.

The present study involved the testing, with this same examination, of 102 current students whose parents had taken it 25 to 30 years ago, also as entering freshmen[2] at Iowa State College. Parent-child correlations were computed by sub-test, and each 1 of the 8 sub-tests was then assigned to 1 of 2 classes on the basis of the magnitude of the correlation obtained. With the several functions thus dichotomized on the basis of the degree of genetic conditioning involved, 2 mean "D" scores (1950-1919) were computed for each of the 127 subjects of the *original* investigation; 1 mean for the functions more largely genetically conditioned (3 sub-tests) and a second for those less largely genetically conditioned (5 sub-tests). The former mean was subtracted from the latter, in each case, and a simple t-test[3] was applied to determine the significance of the difference between the means of the 2 series of "D" scores.

RESULTS

The primary results of this investigation are summarized in table I. It should first be noted that the parent-child r's for sub-test 2 (arithmetic reasoning), and 4 (synonym-antonym) are significant at the 5 per cent level, and that the r for sub-test 7 (analogies) is significant at the 10 per cent level; none of the other correlations in the table even approaches significance or is within 12/100 of a point of these. Accordingly, sub-tests 2, 4, and 7 were designated as representing the more largely genetically conditioned functions (M), and the remaining sub-tests as representing those less genetically conditioned (L). It may then be observed that the mean "D" score, representing an age increment, is considerably larger for the "L" functions than for the "M" functions (4/10 vs. 2/10 of a standard deviation). When this difference was tested for significance over the entire 127 cases, as previously described, a t value of 5.39 was obtained[3]; this is significant above the 1 per cent level of confidence and strongly suggests an inverse population relationship between degree of genetic conditioning and magnitude of age increment.

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[1] This research was done under contract number N70NR-37103 between the Office of Naval Research and Iowa State College; however, the opinions and assertions contained herein are those of the writers and are not to be construed as official or reflecting the views of the Navy Department or the naval service at large.

[2] Parents and children were, thus, tested at approximately the same age.

[3] The obtained value of this is an underestimate of the true value, since the difference, or "D", scores are correlated. However, since the associated probability value is now $<.01$, a correction to make it still smaller was not considered of practical importance.

TABLE 1. MAGNITUDE OF PARENT-CHILD CORRELATION VERSUS MAGNITUDE OF AGE INCREMENT, BY ALPHA SUBTEST

	Following Directions	Common Sense	Disarranged Sentences	Number Series Completion	Information	Arithmetical Reasoning	Synonym-Antonym	Analogies	
	1	3	5	6	8	2	4	7	
	L	L	L	L	L	M	M	M	n
Parent-Child r	.04	.05	.04	.01	.00	.19	.21	.17	102 pairs
Mean D-Score (1950-1919) in δ units	.04	.54	.63	.00	.93	−.10	.55	.14	127

M=more largely genetically conditioned function; L=less
r=.19 (5% level); r=.16 (10% level)
D-score Mn_L=.43; Mn_M=.20

DISCUSSION

Several aspects of these results seem to require a comment. First, it may be argued, and granted, that parent-child correlation is not a good index to degree of genetic conditioning. Perhaps environment does bring about differing degrees of parent-child resemblance in differing intellectual functions. It may, however, be noted that a thread of ability to see various sorts of relationships runs through the M sub-tests, and that 2 of the L sub-tests (common sense and information) are conspicuously informational and dependent upon environmental exposure. At any rate, whatever the true nature of the classifying variable, the classification was effective—something other than chance is presumably operating.

Second, a question may arise here, where all of the obtained correlations are small, as to whether or not differences between them are mere reflections of differences in sub-test reliability. The answer to this is negative—the classification of parent-child r's would remain the same if all coefficients were corrected for attenuation.

For the moment, then, let us assume that the obtained results may be taken at face value. What they seem to indicate is that age is less kind to some more largely genetically conditioned intellectual functions, possibly well saturated with reasoning ability, than to certain other functions which benefit more largely from environmental exposure, and which are perhaps more informational in character. It has been recognized for some time that various mental abilities are differentially affected by age, and it has been implied that problem-solving and informational functions are among those which diverge. It is herein suggested that one of our definitions of the clusters of abilities subject to these recognized differential effects should, perhaps, be based upon their ordering along some genetic versus acquired continuum. The worth of this classifying variable, like that of others, will, of course, ultimately be judged in terms of the extent to which it makes data meaningful and stimulates investigation.

SUMMARY

In the course of a previous investigation (1), 127 males who had originally taken Army Alpha, Form 6, as freshmen of 1918-1919 at Iowa State College were readministered the same test 31 years later. When shifts in score on the 8 sub-tests of which Alpha is composed were examined, substantial gains were observed on half of them—with little or no change on the remaining half.

In the present investigation a measure of

genetic conditioning was obtained by correlating, sub-test by sub-test, the Army Alpha scores of 102 current students at Iowa State with those of their parents who had also taken it as entering freshmen some 25 to 30 years earlier. With the sub-tests classified on this basis as "more" or "less" genetically conditioned, it was observed that shifts in score over the 31 year period were inversely related to degree of genetic conditioning. It is implied that scores on tests of more largely genetically conditioned functions are less inflated by the increased environmental exposure which must accrue with advancing age.

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RETESTING OLDER PEOPLE WITH THE CORNELL MEDICAL INDEX AND WITH THE SUPPLEMENTARY HEALTH QUESTIONNAIRE[1]

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THE *Cornell Medical Index* (abbreviated C.M.I.) has been recommended for use as an aid in taking medical and psychiatric histories of individuals in the age range from 18 to 80. One of the questions that remains open is the degree to which the responses on the questionnaire at one time are consistent with those at a later period. In general, for younger people, there has been evidence that the answers to the questionnaire are very much like those given in an oral history (1). For older people, however, such evidence is lacking. The primary problem to be determined is the degree to which responses to the questionnaire are identical on subsequent re-administrations.

The C.M.I. and the adjunct *Supplementary Health Questionnaire* (abbreviated S.H.Q.) have been described in detail in previous articles (1, 2). The questionnaire and its adjunct are self-administered, paper-and-pencil inventories consisting of questions requiring a Yes or No answer. Essentially, the C.M.I. consists of 195 questions broadly concerned with bodily symptoms, e.g., "Do you need glasses to read?" and with mood and feeling symptoms, e.g.,"Are your feelings easily hurt?" The S.H.Q. consists of 61 additional questions also concerned with bodily symptoms, e.g., "Do you feel cold even on a warm day?" and with mood and feeling symptoms, e.g., "Are you absent-minded?," presumably more relevant to the aging process, not adequately covered in the C.M.I.

The subjects were 24 residents (12 men and 12 women) of a modern institution for the aged and of an apartment house, both under the auspices of The Home for Aged and Infirm Hebrews of New York, and 38 individuals (27 men and 11 women) living in their own homes and attending the William Hodson Community Center and the William I. Sirovich Day Center, two day centers for older people in New York City. In age, the subjects ranged from 57 to 84 years, with an average of 71 years; in education, from one year of schooling to college graduation, with an average of eight years.

Estimates of the consistency of the questionnaires were obtained by having each subject take the C.M.I. and S.H.Q. and then take them again after intervals of five and one-half to seventeen months. The average time interval between the early and later administration of the questionnaires was seven months.

For the C.M.I. and S.H.Q. combined, the correlation between the number of symptoms reported on the early administration and that reported on the later administration is .70. This suggests considerable consistency for the two questionnaires.

A more detailed analysis indicates that the actual items in the two questionnaires are responded to quite stably. The stability of the items was estimated by computing for each question the proportion of subjects maintaining the same response on early and later administration, i.e., the proportion responding "yes" on early and later administration or "no" on early and later administration. For the items, the proportion of subjects maintaining the same response on early and later administration varied from 50 per cent to 98 per cent; for all items in the two questionnaires combined, the average proportion maintaining the same response was 84 per cent. The most stable items (98 per cent of the subjects maintaining the same

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response) were the following: "Do you suffer from asthma?," "Have you ever had T.B. (Tuberculosis)?," "Do you use a hearing aid?," and "Do you have rough patches on the back of your hands or on your back?" The least stable items (50 per cent to 68 per cent of subjects maintaining the same response) were the following: "Do you prefer old friends rather than make new ones?," "Are you set in your ways?," "Do you like to give advice?," "Do you have to clear your throat frequently?," "Do you often get spells of complete exhaustion or fatigue?," "Do you have trouble understanding when four or five people are talking at once?," and "Have you ever had constant severe flashes and sweats?"

The stability of the items does not seem to be related to the kind of item or its wording. A comparison between items referring to bodily symptoms and those referring to mood and feeling symptoms, between items worded very specifically and those worded less specifically, and among items referring to past medical events, those referring to chronic conditions, and those referring to acute or transitory conditions shows no difference in stability.

Although the items in the two questionnaires are quite stable, there is a generalized tendency for the subjects to report fewer bodily symptoms and fewer mood and feeling symptoms on the later than on the earlier administration (table 1). The difference between the mean number of symptoms reported on earlier and later administration is statistically significant for both parts of the C.M.I. and for mood and feeling symptoms for the S.H.Q. For the two questionnaires combined, 61 per cent of the men and 59 per cent of the women reported fewer bodily symptoms, and 74 per cent of the men and 57 per cent of the women reported fewer mood and feeling symptoms. The decrease in the number of symptoms reported on the later administration applies to the majority of the items: 60 per cent of the items referring to bodily symptoms and 79 per cent of the items referring to mood and feeling symptoms. The items showing the greatest decline on the later administration are: "Do you like to be waited on?," "Do you usually get up tired and exhausted in the morning?," "Do you usually have great difficulty in falling asleep or staying asleep?," "Must you do things very slowly in order to do them without mistake?," and "Are you anxious about the future?" The items showing the greatest gain on the later administration are: "Do you need glasses to read at a distance?," "Has a doctor ever said your blood pressure was too high?," "Does your heart often race like mad?," "Do your muscles and joints constantly feel stiff?," and "Do you often have severe burning pain when you urinate?" The tendency for the subjects to report fewer symptoms on the later administration is similar to the finding of a previous study which showed that for a sample of institutionalized and noninstitutionalized men and women, 55 to 91 years of age, there was a tendency for the number of symptoms reported on the two questionnaires to decrease with age for men and to show no change for women (3). This may be attributable, in part, to a tendency by individuals as they grow older to report fewer symptoms because they tend to accept more readily the cultural stereotype that poor

TABLE 1

THE MEAN NUMBER OF SYMPTOMS REPORTED FOR THE CORNELL MEDICAL INDEX AND SUPPLEMENTARY HEALTH QUESTIONNAIRE ON EARLY AND LATER TESTS FOR 62 OLDER ADULTS

Questionnaire	Early Test Mean	Early Test S.D.	Later Test Mean	Later Test S.D.	t
C.M.I.					
Bodily symptoms	25.0	18.1	21.4	16.2	2.5[1]
Mood and feeling symptoms	7.9	8.2	5.3	5.4	3.0[2]
S.H.Q.					
Bodily symptoms	4.3	2.6	3.8	2.3	1.2
Mood and feeling symptoms	6.9	5.3	4.9	3.8	4.6[2]

[1] significant at .05 level.
[2] significant at .01 level.

health is a concomitant of aging, or the particular symptoms are supposed to be stigmata of aging.

Although fewer symptoms are reported by the subjects on the later administration, the magnitude of the correlation between the number of symptoms reported by the subjects on early and later administrations, and the high stability of the items indicate considerable consistency for the two questionnaires over a period of time. In the course of administering the questionnaires, several of the subjects commented on the fact that many questions on the two questionnaires were not particularly relevant to their own health,[1] e.g., questions about early childhood diseases and questions about menstruation for women. If questions not particularly applicable to men and women of this age group had been omitted, the consistency of the two questionnaires may have been greater.

Summary

The problem was to estimate the degree to which responses of older people to the Cornell Medical Index and the adjunct Supplementary Health Questionnaire are identical on subsequent readministrations. The subjects were 24 institutionalized and 38 noninstitutionalized men and women, average age 71, who had completed an average of eight years of schooling.

Estimates of the consistency of the questionnaires were obtained by having each subject take the Cornell Medical Index and Supplementary Health Questionnaire and then take them again after intervals of five and a half to seventeen months. The average time interval between earlier and later administration of the questionnaires was seven months.

There is a generalized tendency for the subjects to report fewer bodily, and mood and feeling symptoms on the later than on the earlier administration. However, the correlation of .70 between the number of symptoms reported by the subjects on the earlier and later administration and the high stability of the items indicate considerable consistency for the two questionnaires over a period of time. If questions not particularly applicable to men and women of this age group had been omitted, the consistency of the two questionnaires may have been greater.

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[1] To meet these criticisms and to include questions more relevant to the health situation of older people, the authors have developed a new health questionnaire, the Columbia Adult Health Inventory, which is oriented more around the older person's adjustment to his bodily, mood, and feeling disabilities than merely around the number and kind of disabilities he reports.

THE PERSONALITY OF THE AGED. A REVIEW

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It is the intent of this introductory paper to review the nature and extent of knowledge concerning the personality of the aged. If such a review were to include only rigorous research studies, it would of necessity be brief, for such studies in the field of personality of the aged are exceedingly rare. It is the purpose of this review to emphasize the dearth of such research and, by outlining pertinent illustrative studies, to suggest ways in which problems worthy of investigation in this field may be conceptualized.

The Present Status

The current status of investigation of the personality of the aged might be characterized as naturalistic and exploratory. A naturalistic stage of study and research precedes that firmly rooted in theory and experiment. The early history of biology aptly illustrates this since this, too, is a field that in large measure is concerned with developmental sequences. The phenomena under scrutiny by biologists were first studied in the field with attention given to readily observable isolated characteristics and reported in terms of rough comparisons. In these beginnings of biology anecdotal material played a definite part. This was the period of fact-gathering, empirical exploration of the field. Rigor, experimental design, and correlations with findings from other fields came slowly and in different segments of the field at different rates. Similarly, in the field of the psychology of aging, this period of increased sophistication has arrived in certain areas such as in the investigation of intellectual functioning, but personality functions are still being examined in a naturalistic, exploratory fashion.

As evidence for this one can cite the fact that much of our present information concerning the personality of the aged is derived from a study of adjustment issues and is primarily service-oriented. Although a service orientation is not incompatible with scientific advance, it can limit the careful control and manipulation of variables so necessary to application of the scientific method. Many individuals concerned with gerontology work intimately and immediately with problems of improving the lot of older people. Unlike child research, for example, researchers in gerontology arrange to report to their constituents as well as to their colleagues—hence the many conferences where both professional and lay people attend with programs designed to cover the entire gamut of problems social and economic, medical, and psychologic. In the psychologic section some attention is inevitably given to adjustment problems. Faced with the necessity of saying something and lacking tested knowledge, *i.e.*, research, the speaker often draws upon anecdote and clinical observation for his information about the personality of the aged. These two aspects—application to adjustment issues and the anecdotal character of the evidence—characterize both the direct and incidental references to personality at the numerous conferences arranged on the problems of aging (5, 6, 7, 11).

Community surveys involving the aged frequently touch upon personality characteristics but do not interrelate one variable, such as personal happiness, with other personality variables. Although falling short of a rigid

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definition of personality investigation, they do lay down parameters for the study of personality and are thus forerunners of such studies.

Psychologic studies of aged psychiatric patients are in the main confined to clinical observations, and research investigation of the personality of nonpsychotic aged individuals is almost non-existent. The psychiatric studies of the aging, moreover, partake of the weakness of much clinical psychiatric research—exclusive concern with patients grouped by diagnostic labels derived from an outmoded nomenclature.

What about the literature concerned more directly with the personality of the aged? Granick (8) in his 1950 review of the literature on the psychology of senility published reports on but 21 studies of the personality of the aged as contrasted with approximately 72 studies devoted to the study of intellectual and learning abilities. Of these 21 personality studies, at least 7 depended upon self-report personality questionnaires, the validity of which is now under well-deserved suspicion. In summarizing the literature on adjustment inventories, Dennis states (4):

> None of the studies of age and adjustment yet conducted seem to offer sound basis for any conclusions . . the criteria for including items have varied, the definitions of the areas to be sampled by the tests have varied, and the purposes for which the tests have been devised have been numerous. Yet no test has been devised so as to yield a comparison of wide age groups in regard to denotable kinds of behavior . . . the comparison of age groups which have been made, using various adjustment measures, have not only used instruments which have doubtful meaning when used for such purposes but they have also failed to obtain samples of satisfactory representativeness. Such limited groups offer poor bases for general conclusions.

In Granick's review, the only other personality instrument other than questionnaire utilized by more than one or two investigators was the Rorschach test. In the 3 reported investigations the usual clinical interpretation of the significance of the various Rorschach factors was lifted completely from the findings with younger groups. The results were interpreted as if there were no question that the usual significance of the Rorschach was unchanged by applying it to older persons. No questions of validity were raised; instead the Rorschach protocols were interpreted on the basis of assumptions derived from other groups. It would seem that the path of caution would call for at least revalidation before sweeping assertions are made on the basis of this technique. Closer attention to this issue is given in the paper by Caldwell (3) on the Rorschach in this symposium.

The great majority of the remainder of the studies of the personality of the aged reported in Granick's review depended exclusively upon short interview techniques. The short interview, a valuable tool for exploratory research, is generally considered to require supplementation from other more objective devices as a check upon the validity of the findings thus derived. It was characteristic of the studies reviewed that the interview-findings were the exclusive source of data.

An indication of the paucity of literature on the personality of the aged may be found in accounts of sponsored research and in the classification of gerontologic research. Shock and Wehrwein (15), in their 1950 report on government-conducted research in gerontology, say nothing about research in personality. Kirk's companion report (10) on university-sponsored research specifically excludes all psychologic investigations, although the scope of the title would clearly call for their inclusion. Five lines are devoted to personality in a chapter of 20 pages on aging research in the account of the first national conference on aging (1). In the classification of gerontologic research problems presented by Simms (16) at the 1950 National Conference on Aging, there is little or no recognition given to the importance of investigations of the personality of the aged. While nowhere explicitly mentioning personality, he does refer to reactions to stress and social adjustment as being worthy of study. Here again is an instance in which the

study of personality is located not in the individual but in the environment. These *correlates* of personality adjustment are important but do not take the place of an emphasis upon investigation of the personality as such.

Shock (14) makes the point that most of the studies in this field report age differences rather than age changes and urges that longitudinal studies are strongly indicated. With this there can be no quarrel, but it is possible to disagree with his further contention that fundamental knowledge must await these longitudinal data. Studies on the intellectual aspects of the aged did not await this highly desirable state of affairs; nor did personality studies of the child.

In spite of the paucity of the research on the personality of the aged and a certain lack of imaginativeness displayed in the attacks upon the problem, it may be that the time has arrived when more rigor will emerge in this segment of gerontologic psychology. The Section on Psychology, Sociology, Education, and Religion of the Second International Gerontological Congress (13) which met in St. Louis in September, 1951, mentioned in its research report the need for going beyond exploratory to carefully designed and thoroughly implemented research. In the section relevant to present interests, 14 suggested studies were briefly mentioned. Throughout most of these problems the motif of personality investigation is apparent. There is specific mention of studies of rigidity, the self-concept, roles, and the study of the personality of the aged as a means of contributing to personality theory.

The report prepared by Greenleigh (9) is the result of several months of travel and reading. In many ways it is a remarkable document with a wealth of detail and fresh points of view. A theme running throughout is that the anatomic and physiologic changes associated with age are met by different aged persons in different ways and actually modify in large measure the response to aging. Anatomic change is only one of the many stresses which enter into the psychologic changes in the aged person. For example, there is no one-to-one correspondence between anatomic change and clinical status. This report also makes explicit the fact that the personality of the individual is the principle source mediating the changes which do take place.

It is the thesis of the present paper that the time is ripe, so far as the investigation of the personality of the aged is concerned, to go beyond the naturalistic stage. It is also now appropriate to make explicit the theoretic implications of and potential scientific values to be found in the study of the personality of the aged quite apart from the service implications of the findings. With these guiding principles, the remainder of this report will consider methods of conceptualizing the personality of the aged and possible studies illustrating these conceptualizations.

Some Future Possibilities

Illustrations of potential studies of the personality of the aged may be considered conveniently from several points of view, such as learning theory, factor analysis, alleged personality characteristics of the aged, environmental limitations, and problems suggested by the various theories of personality organization now extant. Each of these points of view will help to yield, when submitted to careful experimental or statistical observation, the sort of information needed for a theoretic understanding of the personality of the aged.

I might begin with a study based on learning theory which has implications for the personality of the aged. A short digression in order to set the stage is necessary at this point. One aspect of the behavior of old people which might be confused with rigidity of the aged mentioned in the literature is their capacity to ignore irrelevant stimuli. A narrowing of interests is often spoken of as characteristic of the aged. This is designated as a weakness when often it is actually

self-protective. In terms of energy expenditure the older person simply cannot afford to pay attention to as many things as before. No longer are "ships and shoes and sealing wax and cabbages and kings" within their purview. They concentrate upon certain essential activities and give up the rest. "Convenient" deafness might in some instances be an illustration of this capacity to ignore irrelevant stimuli. In terms of current learning theory this ignoring of irrelevant stimuli might be stated as restriction of stimulus generalization. Stimulus generalization might be defined as a process whereby a response established to one stimulus may also be elicited by other stimuli. An apparatus used by Brown and associates (2) would be appropriate for experimental determination of the stimulus generalization of older persons. It consists of a curved plywood panel 6 feet long with 11 frosted lamps in a horizontal row, each lamp equidistant from the subject. Subject lifts his finger from a reaction key wired to a standard electric timer. The subject is instructed to respond by lifting his finger when the center light is flashed on but not to respond to any of the other lights. An error consists in responding to the distracting lights. The hypothesis might be stated: With increasing age stimulus generalization will decrease. In other words, it would be expected that an older group as compared to a younger would make fewer false reactions to the distracting lights. It is apparent that under certain circumstances this restriction of stimulus generalization might prove to be an asset in the personality adjustment and work habits of older individuals.

For the present exposition, factor analysis might be described as a correlational method which permits reduction of a larger array of variables to a smaller number of important variables, thus laying bare the bones of personality organization. Although several studies using factor analytic techniques with aged subjects have already appeared, they center upon intellectual factors. A study of personality factors as they change with increasing age would seem to be a potentially useful research area. This is dependent, of course, upon good techniques which span the years.

An important recurring problem is the question of the manner in which an older person views himself. The old saying, "A person is as old as he feels," has now been translated into the hypothesis, "A person is as old as his self-concept." Classifying her data in terms of a positive to negative and an organized to disorganized self-concept, Mason (12) is reporting her findings for this symposium. With an institutionalized and a self-maintaining sample she is investigating this through a variety of approaches including the Vineland Social Maturity Scale, a self-concept questionnaire, the WAY technique and the Caldwell Picture Series technique.

Another possible study of the self-concept of the aged is suggested by the work of Taylor and Combs (17) with children. They hypothesized on the basis of self-concept theory that better adjusted children would be able to accept more damaging statements about themselves than less well-adjusted children. Sixth-grade children divided into better adjusted and poorer adjusted children on the basis of scores of the California Test of Personality were asked to check a list of somewhat derogatory statements as true of themselves. The better-adjusted group checked significantly more items than did the more poorly adjusted group. The basic design of this study might profitably be applied to older persons.

It is possible to conceptualize the problems of the personality of the aged in terms of social roles. To be sure, the so-called passive role of older people in our society is a product of social factors. But astonishingly little has been done to define the impact on the personality of the aged person of this assigned role. The passive role might be investigated by sociometric technique, by role playing, by time sampling akin to the studies of children, by questionnaire, by projective technique, by staging frustrating situations as in experiments in social psychology, as well as many

other less immediately obvious methods.

There is an extensive literature demonstrating that a considerable number of differing meanings have been given the term rigidity. It is possible for present purposes, however, to confine oneself to the common observation that old people in the face of changing circumstances fail to alter their behavior to correspond to these new circumstances. This has not been experimentally investigated.

The present writer in collaboration with Mensh (18) has recently been working with a variety of behavioral tests that seem to measure this characteristic. Some success has been achieved in differentiating among nonanxious normals, anxious normals, and neurotics in young and middle-aged adults (19). These include measures of perseveration such as forward, reversal, and alternating of Z's; mirror drawing; and certain characteristics of level of aspiration measures. These or similar measures might be applied to younger and older matched groups to determine if the older subjects do display greater rigidity and perhaps to detect qualitative as well as quantitative differences in their reaction pattern.

Although the older person's most difficult adjustments still involve the behavior of other people, an increasingly important source of difficulty is to be found in adjusting to physical things. Perceptual and motor adjustments are no longer static. Unlike the child or young adult, he finds the stair which could be climbed yesterday is not to be climbed today. He is engulfed by a remorseless, ever-narrowing process of limitations set upon his adjustment to physical objects. He retires from work, from his recreation, his church, and from his tennis court, his town, his street, and from the upstairs (or downstairs) in his home. This way of stating the problem has a methodologic advantage over stating it in terms of physical disability. This degree of retirement rather than the extent of physical disability is crucial. Two individuals equally crippled physically are not equally crippled psychologically, and the impact upon personality of physical restriction is in need of investigation. A comparison of the personal reactions of individuals showing varying degrees of physical restriction would be practically and theoretically worthwhile.

Although not stated in the framework of current theories of the nature and consequences of frustration, the literature on the aged is replete with illustrations of the frustrating effects of the aging process. Indeed, the problems of restriction of stimulus generalization, rigidity, and the effects of physical restriction previously mentioned could all be considered in terms of frustration theories. The work of Rosenzweig, Dollard, Lewin, and Freud stated in terms of frustration theory has been neglected in the area under discussion. There has been no rapproachment between their theories and the study of the aged. An illustration of a possible study might be conceived in terms of Rosenzweig's theory of frustration. It will be remembered that in one aspect of this theory, he distinguishes between the direction of aggression as extrapunitive (turned outward on environment), intropunitive (turned on the self), and impunitive (denied). The sheer patterning of aggressive responses in older persons would constitute a worthwhile study. It is also apparent that various differences due to age might be hypothesized. An instrument especially devised for investigation of this theory is known as the Picture Frustration Study. Shown in cartoon form various frustrating situations, the subject is asked to indicate his reply to the frustrating situation. Application to a matched younger and older group would reveal information concerning the way in which older persons meet frustrating situations.

Concerning the current approaches to the structure and function of the personality a shift in point of view is urgently necessary. It would seem that not only should the various theoretic points of view be submitted to empirical test but also that there should be a reconciliation of such findings with the main theoretic body. Any theory of personality

which ignores the functioning of the aged person is to that extent incomplete. If it does not cover the findings of the personality of the aged, to that extent it is a theory of limited scope. Age stands as a challenge to the theories of personality organization. The psychoanalytic, personalistic, field, phenomenologic, and other points of view must eventually grapple with the problem of validation of their theories against changes associated with aging. In another sense it is also a challenge. If a particular theory can show verification of its tenets by application to this virtually uninvestigated group, it gains added lustre at other ages. If the vicissitudes of events in time allow the coherence of personality as conceptualized from a given point of view still to shine through, then the theory is rigorously validated. What happens to Sheldon's cerebrotonics, somatatonics, and viscerotonics, when age takes its toll? What happens to the Oedipus drama in the aged? Application to the aged of the theoretic constructs on which these and other findings are based is mandatory. Until this has been done these theories are inadequate.

Summary

Personality research on aged persons, although in the main naturalistic and exploratory, shows signs of entering a more rigorous phase. The status of the literature is examined in terms of present indications of empirical fact-gathering in a relatively new field with a service orientation and an eye to indications that a new phase has appeared offering many challenging theoretic problems to be investigated. Illustrations of potential studies of the personality of the aged in keeping with this new orientation are given. The areas drawn upon include learning theory, factor analysis, alleged personality characteristics of the aged, environmental limitations and their interaction with personality, and various current theories of personality organization.

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THE USE OF THE RORSCHACH IN PERSONALITY RESEARCH WITH THE AGED

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THE term personality research has been used to describe a variety of approaches to the same problem. To some the term connotes surveys of trait-clusters in various populations; to others it signifies investigations of dynamic processes of interaction in groups; but to virtually every clinician it suggests that area of study for which the Rorschach technique is eminently suited. Although the inception of the Rorschach was within the field of personality aberrations rather than normal personality development, it was designed specifically as a method for studying the personality as a whole. In recent years it is this holistic approach which has received the closest attention from personality theorists. Therefore, as the field of gerontology broadens its scope to encompass personality research, it is not surprising to encounter studies in which the Rorschach is used as one of the major techniques of investigation.

A brief review of the literature will reveal that in these studies there has been a rather uncritical acceptance of the technique as being equally suitable for older age groups as for the younger individuals on whom it was originally standardized. One of the objectives of this paper is to raise the question of whether this assumption is justified.

RORSCHACH STUDIES IN ELDERLY INDIVIDUALS

The developmental changes accompanying increasing age were mentioned rather briefly by Rorschach (10), who commented that the older individual loses the capacity for introversion and becomes more coartated or constricted. He described further influences of age as an increase in stereotypy and a decrease in the freedom of associations and claimed that the protocols of normal subjects 70 to 80 years of age closely resembled those of cases of dementia simplex.

A study by Klopfer (8) in 1946 reported the results of individual examinations of 50 people over 60 years of age, 30 of whom were institutionalized and 20 of whom lived outside an institution. Personality characteristics describing the groups included a slowing down in the intellectual sphere both in terms of productivity and efficiency. The senescents had difficulty thinking conventionally and at the same time showed stereotyped thought processes. For the most part the intellectual ties to reality were adequate but somewhat loose. Their capacity for making use of inner resources seemed diminished, and emotional responsiveness tended either to be egocentric and labile or else highly restricted. The ability to establish satisfactory relationships with others was considerably reduced. Klopfer also mentioned that, while there were some differences between his institutionalized and non-institutionalized samples, the patterns suggested more similarities than differences between the two groups.

Another study was reported by Prados and Fried (9) in 1947. They examined 35 persons ranging in age from 50 to 80 years and reported results in terms of trends for the 3 decades. By this division they hoped to learn something about the evolution of changes in personality structure. Their findings, in brief, were not too different from those of Klopfer except for their observation of greater productivity and more frequent use of both movement and color. They made the interpretation that with increasing age, impover-

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ishment of the creative intellectual faculties occurred, with the oldest subjects resigned to this deficit whereas the younger groups still showed some anxiety about it. Also the capacity for emotional responsiveness and control over instinctual demands diminished with age, resulting in a return to some of the primitive manifestations of early childhood.

The most recent study along these lines is the one published in 1952 by Davidson and Kruglov (5), who were concerned only with institutionalized subjects. The sample consisted of 46 men and women, ranging in age from 61 to 91. Means of the various scoring categories were reported for the total group and for the younger and older subgroups. In addition the authors scored all the protocols on the 17 Davidson adjustment signs which had been established on younger groups. Personality characteristics of the group, as described by the authors, included decreased productivity and drive, faulty perception of reality, bizarre thought processes, and decreased capacity for creative and original thinking. Emotional responsiveness was diminished, and general adjustment was less adequate than that found in younger subjects, with the women showing better adjustment than the men. The outstanding formal attributes of the records upon which these interpretations were based included low number of responses, overemphasis on form responses, high number of poor form responses, relatively few movement responses, extreme paucity of responses to color, and a limited range of interests. Their conclusion that the group showed less adequate adjustment than younger groups may be open to question, as in their sample the average number of adjustment signs was 8 out of 17, while in younger samples it has been found to be 9, a difference of only 1 point.

Table 1 offers a brief summary of these 3 studies, plus previously unpublished results obtained by Caldwell and Watson on a group of 47 institutionalized aged women. The present sample is admittedly a specialized one, the women having a mean Wechsler-Bellevue IQ slightly below the lower limit of the normal range (mean of 85). Any inferences made from the data should therefore be restricted to similar samples. Table 1 also includes for convenience of reference a description of normal expectancies for younger adults as given by Ames and associates (2). A survey of this table reveals a rather high degree of similarity between the findings of the various studies, with the work of Prados and Fried (9) showing the greatest amount of deviation. The minor variations which appear can be accounted for on the basis of sampling differences.

A comparison of the similarity in test protocols as reported by the various investigators provides one method of evaluating the Rorschach for use in personality research with the aged. That is, the fact that different samples have yielded roughly comparable quantitative results indicates that whatever is being measured appears with a fairly respectable degree of consistency. However, more crucial from the standpoint of this paper is an examination of the inferences made about the underlying personality of the subjects as presumably reflected in Rorschach scores. The titles of the 3 studies reviewed, namely, "Personality Patterns of Old Age," "Personality Structure of the Older Age Groups," and "Personality Characteristics of the Institutionalized Aged," respectively, illustrate clearly how Rorschach findings are assumed to be synonymous with personality characteristics. It is significant to note that none of the studies stated as its explicit purpose the establisment of norms for older groups, although it is highly probable that this was implicit in all of them. Logically, it would seem that this should come first.

The conclusions given in all the studies, as well as the meaning implied in the titles, have reflected this willing transposition of the assumed rationale of the Rorschach scoring categories into the older age groups. Implicit in all the investigations is the fact that more credit has been given to the integrity of the test than to the integrity of the subjects. That is, the assumption is made that the

TABLE 1. RORSCHACH FINDINGS IN OLDER SAMPLES AS REPORTED BY VARIOUS INVESTIGATORS

	Caldwell and Watson (Present Study)		Davidson and Kruglov (5)		Prados and Fried (9)		Klopfer (8)	Ames and Associates (2)
Age Group	61–75 N=21 (Women)	76–92 N=26 (Women)	61–76 N=26 (Men and Women)	77–91 N=20 (Men and Women)	61–70 N=12 (Men and Women)	71–80 N=10 (Men and Women)	62–93 N=50 (Men and Women)	Normal Expectancies from Younger Adults
Total R	14.3	14.9	15.0	15.0	23.0	20.0	14.1	20 to 50
W	5.1	6.2					"Overemphasized"	
W%	43.0	47.0	36.7	36.0	52.0	43.0		20% to 30%
D+d	7.6	6.6					"Underemphasized"	
D+d%	48.4	42.3	55.3	57.3	47.1	56.3		50% to 70%
Dd+S	1.5	1.7						
Dd+S%	9.0	10.1	8.0	6.7	.9	.7	"Normal"	10%
Z	13.2	18.4						
F%	61.1	57.5	57.7	58.0	"Normal limits"			50% or less
F+%	74.0	76.0	(80)	(85)	72.7	77.6		75% or more
FC	.2	.3	.2	.8	1.7	.2		2 to 3
CF+C	.6	.4	.6	.2	(1.9)	(.6)		4
Sum C	1.6	1.1	.7	.6	2.7	2.2		About 5
M	1.0	1.7	1.6	1.6	1.9	1.8	1 or 0 in 60%	2 to 3
FM	1.2	1.9	2.3	2.6	5.0	5.1	>M in 70%	1 to 2
c+C′+K	1.4	1.7	1.7	1.4			"Negligible"	2 to 3
H%	15.7	17.6	(15)	(13)				10% to 15%
A%	50.4	46.9	46.8	55.0	45.0	49.0	>50% in 70%	35% to 50%
P	3.6	3.6	3.7	4.3			Only 2 by >50%	5 to 6
O+	.5	.9						
O–	1.1	1.5						
A/C Time	20.1	22.2						
C Time	22.2	23.1						
Rejections	1.2	1.1						
Determinants	4.4	4.3						
Content	5.2	5.3						
DW	.4	.2						5 to 7
Contamination	.1	.2						

Numbers in parentheses refer to approximations gathered from the data when exact figures were not given.

rationale of the test variables does not change with age, and, since different profiles are found at different age levels, these must represent change within the individual. This may well be true, but in view of the lack of conclusive evidence, it seems that one should more parsimoniously assume that either is equally plausible.

Evidence that this tendency to borrow rationale from widely divergent age groups can be misleading is offered in a study by Balinsky (3), who did a factor analysis of the Wechsler-Bellevue with large numbers of subjects in 6 age groupings from 9 to 60. In emphasizing the necessity for taking into consideration the age of the subjects when interpreting test results, he stated:

> The same test, given to a person of a certain age, may not be measuring the same abilities in him that it would measure when given to an older or younger person. Even though the whole intelligence scale may yield the same factors for a wide span of years, the separate tests that compose the scale may not necessarily be described in terms of the same factors from age to age.

In preparing the present discussion, an attempt was made to examine the available evidence that Rorschach interpretations traditionally applied to younger groups could legitimately be employed with elderly subjects. This was done in two ways: first, by computing correlations between advancing age and certain Rorschach scoring categories, and, second, by correlating Rorschach variables and certain measures of intellectual functioning.

Correlations Between Age and Rorschach Responses

Although all the studies considered here, with the exception of the one by Klopfer (8), have made some attempt to relate results to the process of aging by reporting separate figures for younger and older subgroups within the samples, the quantitative relationship between the variables and advancing age has not been established. In the present investigation this was attempted in the following manner. On the basis of what has been written about the rationale of the different Rorschach variables, and holding as a criterion personality characteristics frequently attributed to older subjects, predictions were made about the relationships which should emerge with increasing age. These predictions were as follows: Negative correlations should appear with total number of responses (R), number of whole responses and per cent of whole responses (W), number of popular responses (P), per cent of good form responses (F+), number of different determinants used, number of content categories, number of human movement responses (M), animal movement responses (FM), form-color responses (FC), color-form plus pure color responses (CF+C), total color responses (Sum C), sum of all achromatic responses (c+C′+K), human responses (H), Beck's organization score (Z), and good original responses (O+). Positive correlations were predicted with number and per cent of usual details (D), per cent of animal responses (A), per cent of responses determined by form alone (F), number of rejections, number of poor originals (O−), confabulatory responses (DW), contaminations, and reaction time to both the achromatic and chromatic cards (A/C Time and C Time).

In the present sample of 47 cases with a 31-year age spread (see table 2), only 2 age correlations were significant at the 5 per cent level, with both of these in the direction opposite from that predicted on the basis of rationale. Between age and good original responses (O+) and between age and number of human movement responses (M), correlations of .37 and .35, respectively, were found. No doubt the restriction of the age range tended to reduce the number of significant relationships, but to extend such a sample in a downward age direction and secure any sort of comparability is extremely difficult. Furthermore, the age range included in these calculations represents that part of the age curve which in many ability studies shows the most rapid and radical change. This absence of significant relationships suggests that at least in this portion of the age curve such variables

Numbers in parentheses refer to approximations gathered from the data when exact figures were not given.

are related less to age *per se* than to other as yet unidentified factors which may or may not bear a relationship to age.

Correlations Between the Rorschach Variables and the Wechsler-Bellevue and Wechsler Memory Scale

Another method of establishing whether or not, when dealing with older subjects, one is justified in attributing traditional meanings to Rorschach variables is to relate these variables to other instruments about which some data are available for older subjects. There is little doubt that thus far the greatest amount of psychologic work in gerontology has been concerned with the cognitive functions. Because of its tremendous clinical popularity the Wechsler-Bellevue has been employed in many of these studies. Although no one would claim that estimating intelligence is one of the areas in which the Rorschach operates with greatest precision, it does purport, as an omnibus test, to appraise the intellect as one facet of the total personality.

Rorschach (10) originally suggested as 7 indicators of intelligence a preponderance of good form responses (F+), large number of kinesthetic responses (M), large number of whole responses (W), an optimal relation of whole responses to usual and unusual detail responses (W to D and Dd), orderly sequence, relatively few animal responses (A per cent), and a number of good original responses (O+). There have been many attempts to verify these indicators. Hertz (7) has reported substantial correlations between scores on intelligence tests and F+ per cent and slightly lower ones with total number of responses, number of human movement responses, and number of whole responses, but all in the expected direction. Beck's Z score (4) has also been frequently mentioned by many recent investigators with somewhat contradictory findings. Goldfarb (6) found low-order positive correlations with other measures of intelligence and Z but higher correlations when only Z occurring in F+ responses was scored.[1] Wishner (12), studying a group of 50 neurotic adults, found Z to be the most consistent single indicator of intelligence. However, he made no adjustment for the influence of the total number of responses upon Z, which may actually account for much of the relationship. In his group total number of responses (R) and number of whole responses (W) also correlated highly with various scores, but F+ per cent did not relate significantly to a single Wechsler-Bellevue category. Number of human movement responses (M) showed a significant relationship to only one subtest of the Performance Scale. More recently Altus and Thompson (1), studying college undergraduates, found the number of human movement responses (M) and number of whole responses (W) to be the most reliable and valid indicators of intelligence, with movement responses definitely the more valid. In their group high F+ per cent and low animal per cent did not discriminate. Tucker (11) found animal movement plus inanimate movement (FM+m) to be as good an indicator of intelligence as human movement (M) in a group of adult neurotic veterans. Wittenborn (13) found that neither total reponses (R), whole responses (W), nor movement responses (M) had sufficient discriminatory power in a group of college students, but that total number of responses showed a slight tendency to be positively related to several measures of ability. From this brief review it is obvious that there has not been complete agreement as to what the intellectual indicators are in any group.

In the present sample of 47 women, data from the Wechsler-Bellevue Intelligence Scale and the Wechsler Memory Scale were also available. Without establishing any *a priori* hypotheses as to which Rorschach factors would be related to intelligence as measured by these instruments, product-moment coefficients were calculated between all the Rorschach variables and the weighted scores, IQ's, and individual subtest scores of the Wechsler-Bellevue and with total score and subtest scores of the Wechsler Memory. In table 2 are given the significant correla-

[1] Readers unfamiliar with Rorschach scoring symbols may refer to Appendix 1 for definitions.

Table 2. Significant Correlation Coefficients between Rorschach Variables and 2 Cognitive Measures—the Wechsler-Bellevue Intelligence Scale and the Wechsler-Memory Scale—in a Group of Institutionalized Aged Women

TABLE 2. SIGNIFICANT CORRELATION COEFFICIENTS BETWEEN RORSCHACH VARIABLES AND 2 COGNITIVE MEASURES—THE WECHSLER-BELLEVUE INTELLIGENCE SCALE AND THE WECHSLER-MEMORY SCALE—IN A GROUP OF INSTITUTIONALIZED AGED WOMEN

	Full Scale IQ[1]	Verbal IQ	Performance IQ[1]	Full Scale Score[1]	Verbal Score	Performance Score[1]	Deterioration Ratio[1]	Information	Comprehension	Digit Span	Arithmetic	Similarities	Vocabulary	Picture Arrangement[1]	Picture Completion[1]	Block Designs[1]	Object Assembly[1]	Digit Symbol[1]	Wechsler Memory Total	Information	Orientation	Mental Control	Logical Memory	Visual Reproduction	Associate Learning
Age			.54																			−.30			
Total R																									
W																									
W%																									
D+d																									
D+d%																									
Dd+S																		.33							
Dd+S%																									
Z		.35		.34																					
F%		−.48		−.47	−.48		−.42																		
F+%		.46	.33	.36	.49	.33	.42		.32		.29	.36		−.39		−.54		−.37	−.31					−.33	−.29
FC																		−.45	.35			.29			
CF+C																									
Sum C											.41											.30			
M										.37												−.31			
FM		.34																							
c+C′+K		.41	.31	.39	.35				.32	.30			.31												
H%				.34									.35												.32
A%																									
P			−.29																						
O+		.33						.40												.39					
O−								−.37			−.29														
A/C Time																					−.55	−.34			
C Time																									
Rejections												.30													
Determinants		.39		.38	.38		.33	.29										.38	.33				.42	.32	
Content			.36			.32				.40			.32												
DW																									
Contamination											.31											−.29			

[1]N = 39 cases. In all other comparisons, N = 47 cases.

tions which emerged from these calculations. For convenience of reading all coefficients which were non-significant have been omitted. There are only 66 significant correlations, a figure which is not large but which is greater than would be expected on the basis of chance alone.

Among the most frequently mentioned "signs of intelligence," total number of responses (R) and number of whole responses (W) did not correlate with a single objective measure. The organization score (Z) was found to be related to both Full Scale IQ and Verbal IQ, and human movement responses (M) to Full Scale IQ. Number of good originals (O+) also bore a significant relationship to Full Scale IQ. Animal per cent correlated negatively with verbal IQ.

It will be readily observed, however, that there were some Rorschach variables which bore a more consistent relationship to the Wechsler scores. F+ per cent showed a significant relationship to 13 of the Wechsler scores, only one of which (–.46 with Digit Symbol) was not positive. This seems to offer ample proof that the quality of form perception is definitely related to intelligence in this sample. The two other categories showing the greatest number of significant relationships were per cent of responses determined by form alone (F per cent) and a score seldom included in Rorschach investigations —number of different determinants used by the subject. Both of these showed a consistent pattern throughout, with the relationship of F per cent being always negative and that of the number of determinants always positive. Four other categories which showed a total of 4 or more significant relationships—number of shading and achromatic responses (c+C′+K), number of animal movement responses (FM), number of poor originals (O–), and number of content categories—all seem to fit together into a meaningful pattern suggesting that intelligence may manifest itself somewhat differently in a population of this sort. That is, when relatively few responses are determined by only the most obvious elements of the stimulus, a greater variety of the other elements of the stimulus may be perceived, thus permitting greater freedom of associations. Such an individual who selects a greater variety of the stimulus elements is perceptually more responsive to his environment, a fact which should be reflected in his performance on objective intelligence measures. Until the relationships were ordered in this way, it was especially difficult to account for the 5 significant correlations between Wechsler scores and the number of shading and achromatic responses. These are ordinarily interpreted as anxiety indicators, in which case their correlation with functioning intelligence, if any, should be negative. In the present sample, however, their mere presence in a record may possibly be another indicator of a greater capacity to respond to perceptual subtleties. This greater perceptual awareness seems to be crucial in registering even a moderately high level of intellectual functioning by means of the Rorschach in this group of aged subjects.

From these observations comes the hypothesis that a certain critical limen of perceptual flexibility must be crossed before the Rorschach is a valid measure of any significant personality variable in the aged. It is important to know if a decrease in perceptual selectivity occurs as a consequence of the aging process, but, if so, this in itself cannot be taken as evidence of a decrease in the capacity for fantasy expression, reduction in intensity of emotional expression, etc., to borrow but a few typical Rorschach descriptive phrases. The data presented here should forcefully remind one that the Rorschach technique is first and foremost a perceptual test, and when dealing with an older sample we have almost invariably a group in which perceptual acuity is somewhat reduced. To date no attempt has been made to control this factor in a Rorschach study with older age groups. Therefore, it should not be forgotten that an unknown quantity of what has been termed impoverishment of personality in the aged can represent merely perceptual impoverishment, which may be

more physiologic than psychologic.

SUMMARY

The growth of interest in personality studies in the field of gerontology has been paralleled by an increase in the number of studies using the Rorschach technique as a means of studying the personality organization. It has been the purpose of this paper to caution against the use of this or any other instrument until something is known about its sensitivity within the upper age range. Evidence has been submitted to suggest that a careless acceptance of the presumed meanings of Rorschach variables which have been developed from investigations of other age groups is injudicious. Now that normative data on various samples which compose the older population have been accumulated, it would seem that the next move should be directed toward experimental validation of the instrument for this particular segment of the age distribution.

The research data presented in this paper were collected by the author while on the staff of the Division of Medical Psychology, Department of Neuropsychiatry, of the Washington University School of Medicine. Statistical analysis of the data was done in collaboration with Dr. Robert I. Watson, then of the same staff. In this connection both the writer and Dr. Watson wish to thank Professor Philip H. DuBois and Mr. Tom Smith of the Department of Psychology, Washington University, for their advice and assistance. The paper was written subsequent to the appointment of the writer to the Department of Psychology, Northwestern University. Grateful recognition is made of the help given by Dr. Watson in analyzing the data and in preparing the paper.

APPENDIX 1

Explanation of Rorschach Scoring Symbols

Total R	Total number of responses given to the test
W	Responses using the entire area of the ink blot
D	Responses to large details of the blots
d	Responses to small details of the blots
Dd	Responses to unusual details
S	Responses to the white space rather than to the blot itself
Z	A quantitative rating of the organizational quality of a response
F	Responses determined by the form or shape of the blots
F+	Responses in which the perceived form corresponds closely to the actual shape of the blot
FC	Responses determined primarily by the form of the blot but with color also incorporated
CF	Responses determined primarily by color but with shape also considered
C	Responses determined entirely by color with formal elements disregarded
Sum C	A weighted score based upon all responses utilizing color
M	Responses in which there is perception of movement in human figures
FM	Perception of movement in animal figures
m	Perception of movement in inanimate objects or abstract forces
c+C'+K	Responses in which the shading of blots produces an impression of texture, diffusion, or vista, or in which black is used as color
H	Content of the response is a human figure
A	Content of the response is animal
P	Responses frequently elicited by a given blot area
O+	Responses rarely associated with a given area which are of good form quality
O-	Responses rarely associated with a given area which are of poor form quality
A/C Time	Average time before responding to the achromatic cards
C Time	Average time before responding to the chromatic cards
Rejections	No response given to one or more cards
Determinants	The number of different determinants of responses used in a given record
Content	The number of different content categories employed in a given record
DW	Confabulated responses, i.e., responses to the whole blot generalized from an initial response to a small detail
Contamination	Spoiling of a response by giving two incompatible interpretations to the same area

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SOME CORRELATES OF SELF-JUDGMENTS OF THE AGED[1]

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RECENTLY, in the field of personality theory much attention has been paid to the self-concept theory of personality organization. This theory maintains that the self-concept, or the way in which an individual views himself, is the primary directional factor in the individual's personality and is instrumental in determining the individual's level of adjustment. Thus, the concept an individual has of his own self-worth becomes the force which governs his basic motivations and levels of aspirations. Raimy (14) is usually given credit for the first formal statement of this view in 1943, but related lines of thinking have been noted in the writings of James (9), Allport (1), Murphy (12), and in Lecky's self-consistency theory (10).

Raimy (14) considers that "what a person believes about himself is a generally accepted factor in the social comprehension of others." Rogers (15) in observations on the organization of personality points out that "when all of the ways in which the individual perceives himself—all perceptions of himself in relation to others—are accepted into the organized conscious concept of the self, then this achievement is accompanied by feelings of comfort and freedom from tensions which are experienced as psychological adjustments." Snygg and Combs (17) in their phenomenalogic approach to the explanation of psychologic behavior view the self-concept as that "aspect of the phenomenal field" which primarily determines individual behavior. These authors point out that just as a realistic positive attitude toward one's own self-worth leads to a high level of personality adjustment, an unsatisfactory or inadequate self-concept will place very real limitations upon an individual's behavior and level of adjustment.

The conceptualization of ego-involvement presented by Sherif and Cantril (16) is in many respects the equivalent of the self-concept theory. Their assertion that "the ego of a growing girl or boy develops as a consequence of various contacts with the surrounding physical and socio-economic milieu" is parallel to the developmental aspects of the self-concept theory. Observation and clinical experience have led many psychologists to the belief that the individual's concept of himself is of the utmost importance in the understanding of the dynamics of personality development and adjustment. A study of the self-concept of the aged then should provide useful information concerning personality development in later maturity.

EXPERIMENTAL DESIGN

It was hypothesized that the variables of age, attitude toward aging, length of residence at present address, educational level, judgment of health status, family success, social success, years since employment, occupational success, religious importance, number of free time activities, mood of life, present mood, present level of social maturity, and intelligence are significantly related to the views an aged individual holds of himself and that these views or aspects of the self-concept should be considered along 1) a positive-to-negative continuum, and 2) an organized-to-disorganized continuum.

The self-concept is defined as the way in which an individual views himself. Opera-

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[1] The present study is a part of a larger study completed in partial fulfillment of the requirements for the Ph.D. degree, Washington University, 1954.

tionally then, the aspects of the self-concept with which this study deals are the individual's view of his social competence (as measured by the Vineland Social Maturity Scale (6)), his attitudes toward his health, friends, work, economic security, religion, feeling of usefulness and happiness (as measured by the Chicago Attitude Scale (3)), his positive or negative attitudes toward himself (reflected in responses to the Self-Concept Questionnaire), indications as to whether or not he has any clear conception of who he is as an individual (reflected in his replies to the W.A.Y. technique (2)), and his positive and negative affectively-toned reactions to the figures with which he most readily identifies (reflected in stories elicited by the Caldwell Picture Series technique (4)).

To investigate the relationship between the stated environmental variables and the defined aspects of the self-concept 3 groups were studied. A group of 60 indigent subjects above the age of 55 who had been institutionalized in the St. Louis City Infirmary was compared with a group of 30 subjects of middle-class status and above the age of 60, who were still able to maintain an independent existence. This latter group was drawn from individuals who were seen for routine checkup by a physician specializing in geriatric medicine. This comparison yielded information concerning the individual's attitude toward self when age was held constant and economic status and living conditions varied. A third group of 30 young adults also was studied to evaluate changes in self-conceptualization of 2 different age groups. These subjects were parents of clinic patients at St. Louis Children's Hospital. Their clinic status indicated limited financial background and allowed a comparison of the attitudes of this group and the aged institutionalized group.

Critical to the design was the manner in which the data concerning the environmental variables were obtained. Although it would have been possible to ask each subject to report on the environmental variables, it was recognized that because of poor memory resulting from the ravages of age and normal psychologic defences the validity of such reports could be open to question. Hence, an independent informant was asked to report on these variables for each subject. Two research nurses, a physician specializing in geriatric medicine, and husband and wife teams acted as informants for the aged institutionalized, the aged independent, and the young adult groups, respectively.

The informant's responses to a controlled interview provided information about the subject's age, attitude toward aging, length of residence at present address, educational level, judgment of health status, family success, social success, years since employment, occupational success, religious importance, number of free-time activities, mood of life and present mood; a measure of the subject's present level of social maturity was obtained from the informant's report of each subject's social functioning on the Vineland Social Maturity Scale (6); and the Kent E.G.Y. Scale (18) administered to each subject provided a measure of intellectual level. Hence, data on 15 environmental variables were obtained from these 3 sources. A battery of 5 psychologic tests administered to each subject provided 18 measures of aspects of the self-concept. Sixteen of these measures were considered along a positive-to-negative continuum of attitudes while only 2 measures were considered along an organized-to-disorganized continuum.

Because of the problems encountered in the selection of psychologic tests suitable for measurement of aspects of the self-concept in an aged population a brief description of each instrument and the rationale for its use in the study is included.

The Vineland Social Maturity Scale (6) measures social competence by providing a detailed outline of performance in which individuals show a progressive capacity for looking after themselves and for participating in activities which lead toward adult independence. The items of the scale are arranged in order of increasing difficulty ranging from birth to 25 years or older with a maximum score of 117 successes. Though the scale has

often been considered to be limited to use with children, it was standardized throughout the age range from infancy to 30 years, with a scattering of subjects ranging in age to 60 years. The data indicate that average scores show some selective variability but no steady rise in social competence past the age of 25. One exploratory study utilizing this tool (5) suggests that social effectiveness gradually declines in later maturity. The subject's view of his social competence seemed an important aspect of the self-concept to be studied. To measure this the scale was administered in a non-directive fashion, hoping to elicit the subject's spontaneous views of how he believed he was functioning socially.

The Kent E.G.Y. Scale (18) provided a rough measure of intellectual level. It consists of 10 questions drawn from everyday general information which have been shown to correlate with general intelligence. Typical questions are: "What are houses made of?" "Tell me the name of some fish." "At what time of day is your shadow the shortest?"

The "W.A.Y." technique (2) requires the subject to respond to the question "Who are you?" with 3 answers. Though the procedure is still in the exploratory phase, normative data are available. The responses were scored by the number of categories represented by each subject's responses, reflecting whether or not the individual had any clear concept of who he was as an individual, i.e., well organized self-concept, and, also, on the basis of the positive-to-negative affective tone of his responses.

The Self-Concept Questionnaire, an instrument especially designed for the study, consists of 26 statements taken from Fiedler's Q-sort statements (7) and from statements which 3 experienced psychologists deemed pertinent to the self-concept of an aged population. Examples of these statements are: "I keep busy most of the time." "I get along well with other people." "My health is as good as most people my age." "I enjoy living now as much as I used to."

Six psychologists rated the statements according to their positive or negative tone. The 6 agreed perfectly on all but 2 items. On these items 5 out of 6 psychologists agreed, which provided adequate judgmental validity for the technique. Test-retest reliability was established in a sample of 25 members of the institutionalized group who were re-examined two to four weeks after the original testing. The rank order correlation of .64 compares favorably with other tests of this type.

On the Chicago Attitude Scale (3) the subject was asked to report his views about his health, friends, work, economic security, religion, feeling of usefulness, happiness, and family. Havighurst (8) defines the scale as a measure of the person's attitudes about himself. As such, it complied with the operational definition of the self-concept. In addition, it is the one test which has been adequately standardized on an aged population. The validity (.53 to .54) and reliability (.72 to .95) reported for the test are considerably above the average for a test of this sort. Since the scale is scored on the basis of 6 of the 7 items for each of the sub-tests receiving a positive or negative weight with the seventh item receiving no weight, it was possible to determine the number of positive statements made about the self on each sub-test. Also, as there were 3 positive and 3 negative statements within each subtest the number of contradictory responses made by each subject could be tabulated as a measure of the degree of organization of the self-concept.

The Caldwell-Picture Series (4) utilizes Murray's Thematic Apperception Test (13) for a theoretic background. It consists of 15 pictures depicting scenes typical of experiences frequently encountered by aged individuals. The instructions to the subjects are: "You know a picture frequently tells a story. Look at these pictures and tell me the story they suggest to you." The feeling-tone associated with the figure in the card with which the subject most readily identified was used as an indirect measure of the view of himself on a positive-to-negative continuum. Positive feeling tones were characterized by

feelings of pleasantness, satisfaction, or elation; dejection, tension, or sadness were typical of negative feeling tone, and stories which no mood could be detected were classified as neutral.

After responding to the 15 cards with stories, the subject was asked to pick the 4 cards which he believed were most like how he felt about himself and the 4 which were least like what he felt about himself. From each group of 4 he was asked to pick the 1 which was most like himself and the 1 which was least like himself. This yielded a forced sort into piles of 1, 3, 7, 3, 1. This procedure was repeated but the subject was asked to sort this time on the basis of the cards he considered were most like and least like an ideal person. Thus, a measure was obtained which indicated the difference between the way the individual regarded himself and the way he regarded an "ideal self."

It was necessary to transform the data obtained from the controlled interview administered to the informant into quantitative scores. With the variables of age, length of residence, years since employment, number of activities, and educational level no problem was involved, since these data were obtained in numerical form. For the variables of attitude toward aging, health judgment, family success, social success, occupational success, religious importance, mood of life and present mood, numerical values were assigned on the basis of whether the judgments were positive, negative, neutral, or some variant of this continuum. The Kent E.G.Y. Scale and the Vineland Social Maturity Scale were scored according to the directions in the manuals (6, 18). Data on the 15 environmental variables were obtained in this manner.

Data on the 18 aspects of the self-concept were obtained from the quantification of the 5 psychologic tests administered to each subject. The Vineland Social Maturity Scale administered to each subject, the W.A.Y. technique, and the Chicago Attitude Scale, were scored in the usual fashion (6,2,3). The Self-Concept Questionnaire was scored on the basis of the number of positive views the subject held of himself, with 26 maximum possible score.

Each of the 15 stories elicited by Caldwell Picture Series was rated according to the dominant negative, neutral, or positive feeling tone of the story. To check the final judgments made by 1 rater for all subjects, the 20 protocols which had been originally rated were re-rated after a four week interval by the psychologist making all of the subsequent ratings. A rank order correlation of .95 indicated a sufficiently high level of consistency in the ratings. Finally, according to a technique used by Matarazzo (11) all words, phrases, or sentences in the stories which referred to the longevity of the individual by reflecting a concern with either extreme of the age continuum were tabulated. The total count was the "longevity score," indicating the preoccupation of the individual with age. Typical reference were: young, younger days, grandchild, children, old, elderly, old time picture, grandma, old fashioned people.

Statistical analyses were made to determine the differences and similarities between the way on which the 3 groups were judged on the 15 environmental variables and also on their attitudes of self-worth reported on the measured aspects of the self-concept. The major analysis of the study was designed to test the relationship between the environmental variables and the measured aspects of the self-concept.

RESULTS

Statistical Analysis of the 15 Environmental Variables

Means and standard deviations were calculated for the respective informant's judgments of the 3 groups. To test the significance of the mean differences between the 3 groups compared simultaneously analyses of variance were calculated. The significance of the mean difference between each possible pair of groups was established by *t*-tests. Bartlett's chi-square and *F*-ratio tests of homogeneity

TABLE 1.

MEANS, STANDARD DEVIATIONS, *F*'s, *t*'s, BARTLETT'S CHI-SQUARES, AND *F*-RATIOS FOR ENVIRONMENTAL VARIABLES FOR GROUP I, 60 AGED, LOW-ECONOMIC, INSTITUTIONALIZED SUBJECTS; GROUP II, 30 AGED, HIGH-ECONOMIC, NON-INSTITUTIONALIZED SUBJECTS; AND GROUP III, 30 YOUNG, LOW-ECONOMIC, NON-INSTITUTIONALIZED SUBJECTS.

	Age[1]	Attitude Toward Aging[2]	Length of Residence[1]	Health Judgment[4]	Family Success[3]	Social Success[3]	Years Since Employment[1]	Occupational Success[3]	Religious Importance[2]	Number of Activities	Mood of Life[3]	Present Mood[2]	Kent EGY Scale	Informant's Social Maturity Rating	Educational Level[1]
GROUP I															
Means	74.22	2.25	3.87	3.48	2.28	2.13	10.02	2.38	1.52	1.45	2.65	1.43	14.38	70.35	5.12
Standard Deviations	8.03	.74	2.76	.81	.86	.83	9.50	.66	.50	1.07	.65	.50	6.71	10.69	3.24
GROUP II															
Means	70.20	2.27	24.83	3.37	2.73	2.67	1.50	2.83	1.67	2.10	2.70	1.53	27.83	105.30	10.80
Standard Deviations	7.95	.60	15.94	.71	.51	.65	3.37	.42	.47	1.40	.64	.50	5.14	4.91	3.84
GROUP III															
Means	34.13	2.33	7.70	3.77	2.80	2.87	.37	2.83	1.93	2.47	2.80	2.00	27.13	105.25	9.80
Standard Deviations	5.55	.65	9.81	.62	.54	.45	1.20	.37	.25	1.20	.54	.00	6.34	1.43	1.76
F (Groups I, II, and III)	298.37**	.43	44.97**	2.31	6.85**	17.47**	25.16**	9.68**	8.12**	7.78**	.58	17.62**	123.29**	225.44**	7.36**
t For Groups I and II	2.38*	.11	9.54**	.68	2.80**	3.12**	5.41**	3.69**	1.53	2.39*	.36	1.05	8.52**	17.36**	7.18**
t For Groups I and III	28.70**	.54	1.75	1.67	3.21**	4.56**	6.13**	3.69**	4.16**	3.74**	1.06	5.97**	8.02**	17.33	5.91
t For Groups II and III	18.48**	.37	6.75**	2.06*	.36	1.09	.07	.00	2.23*	1.18	1.06	4.25**	.43	.00	1.13
Bartlett's Chi-square (Groups I, II, and III)	8.16*	5.43	119.43**	7.06*	16.00**	10.76**	109.45**	20.10**	18.36**	4.13	4.49	4.32	5.57	122.27**	5.70
F—Ratio for Groups I and II	1.02	1.58	33.34**	1.31	2.81**	1.61	7.43**	2.40**	1.13	1.71	1.04	1.01	1.47	4.70**	1.41
F—Ratio for Groups I and III	2.09**	1.32	12.68**	1.72*	2.50**	3.75**	62.99**	3.14**	4.03**	1.26	1.46	.00	1.12	55.29**	1.42
F—Ratio for Groups II and III	2.05*	1.16	2.64**	1.32	1.12	2.32**	7.94	1.27	3.58**	1.35	1.40	.00	1.65	11.75**	2.00*

[1] Unit of measure in years.
[2] Measured on a scale from 1 to 2, inclusive.
[3] Measured on a scale from 1 to 3, inclusive.
[4] Measured on a scale from 1 to 5, inclusive.
* Significant at .05 level of confidence.
** Significant at .01 level of confidence.

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of variance were calculated. The results of these analyses are reported in table 1.

The mean informant judgment for the 3 groups compared simultaneously was significantly different except on the variables of attitude toward aging, family success, and present mood. There was a consistent trend in that the informants judged the aged institutionalized group to be the most poorly adjusted, the aged independent group next, and the young adults the best adjusted.

The mean judgments for the aged institutionalized group and the aged independent group were significantly different on all but 5 variables. Despite the wide difference in economic status and present living conditions, no difference occurred in the judgment of the 2 aged groups on the variables of religious importance and present mood.

The comparison between the judgments of the aged institutionalized and the young adult groups showed greater differences. Length of residence was the one additional variable on which no difference occurred.

The comparison of the aged, high-economic, independent group and the young, low-economic group showed no difference on judgments of family success, social success, years since employment, occupational success, number of activities, intelligence, present level of social maturity, and educational level. The lack of difference in intellectual level and present level of social maturity between these 2 groups may indicate that in their prime the high-economic group had attained a higher level of functioning and the similarity in present functioning between these groups suggests that as the aging process sets in, general functioning levels tend to be reduced.

Tests of homogeneity of variance showed significantly different variances on most of the judgments. Attention to direction or size of variance did not produce evidence of significant trends, however.

Statistical Analysis of the 18 Measures of Aspects of the Self-Concept

Means and standard deviations were calculated for the 18 measures of aspects of the self-concept from the data obtained from the 5 psychologic tests. To establish the significance of the differences between the 3 groups *F*'s, *t*'s, Bartlett's chi-squares and F-ratios were calculated. These results are reported in table 2.

On the questionnaire type of tests the aged institutionalized group reported the most negative view of self-worth, the aged independent group next, and the group of young adults the least negative view.

The analysis of the data from tests which were more projective in nature showed a reverse trend. It was noted that the lowest mean number of negative stories elicited by the Picture Series was made by the aged institutionalized group, while the aged independent and the young adult groups responded with a significantly greater mean number of negative stories. Rather than contradictory evidence this suggests that since the aged institutionalized group was surrounded daily by evidences of decay in old age, this group was less threatened by pictures depicting scenes pertinent to an aged group than individuals participating in everyday life. Therefore, although essentially more negative in their views of self-worth the aged institutionalized group views old age *per se* in a less threatening fashion than does an aged independent group and a group of young adults.

The analysis of mean differences among the "difference scores" obtained from the sorting technique showed a greater difference between view of "self" and "ideal" for the aged institutionalized group than was shown by the other 2 groups. It will be noted, however, that one-half to one-third of the groups could not complete this task.

Comparison of the mean test performance of the aged institutionalized and the aged independent groups showed significantly different mean test scores on all but 4 aspects of the self-concept. It was of significance to note that no difference occurred in the attitudes of the 2 aged groups in their attitudes toward health and feeling of usefulness. This

[1] Unit of measure in years.
[2] Measured on a scale from 1 to 2, inclusive.
[3] Measured on a scale from 1 to 3, inclusive.
[4] Measured on a scale from 1 to 5, inclusive.
* Significant at .05 level of confidence.
** Significant at .01 level of confidence.

TABLE 2.

MEANS, STANDARD DEVIATIONS, *F*'s, *t*'s, BARTLETT'S CHI-SQUARES, AND *F*-RATIOS FOR MEASURED ASPECTS OF THE SELF-CONCEPT FOR GROUP I, 60 AGED, LOW-ECONOMIC, INSTITUTIONALIZED SUBJECTS; GROUP II, 30 AGED, HIGH-ECONOMIC, NON-INSTITUTIONALIZED SUBJECTS; AND GROUP III, 30 YOUNG, LOW-ECONOMIC, NON-INSTITUTIONALIZED SUBJECTS.

	Subject's Social Maturity Rating	Chicago Attitude Scale Health[3]	Friends[3]	Work[3]	Economic Security[3]	Religion[3]	Feeling of Usefulness[3]	Happiness[3]	Family[3]	TOTAL[6]	Number of Contradictions[4]	Self-Concept Questionnaire[5]	W.A.Y. Categories[1]	W.A.Y. Affect[3]	Picture Series Negative Stories[4]	Neutral Stories[4]	Positive Stories[4]	Longevity Score	Sorting Technique
GROUP I																			(N=34)
Mean	72.68	3.59	3.38	2.83	2.70	5.22	3.40	2.87	4.03	28.02	6.12	16.17	1.93	3.95	5.52	5.22	4.18	8.48	12.59
Standard Deviation	7.76	1.88	1.53	1.13	1.00	1.23	1.49	1.81	1.14	7.17	2.74	4.70	1.01	1.19	3.33	3.64	2.98	4.75	2.93
GROUP II																			(N=21)
Mean	105.93	3.73	4.63	3.60	4.37	4.07	3.93	3.60	5.13	33.06	1.70	18.67	2.43	4.20	8.20	3.39	2.83	11.43	7.33
Standard Deviation	5.42	1.48	1.80	1.52	1.17	2.20	1.44	1.80	1.09	7.32	1.98	3.32	.38	1.45	3.05	2.58	2.60	6.42	5.39
GROUP III																			(N=30)
Mean	105.23	4.90	5.50	4.83	3.20	5.00	5.50	4.90	5.70	39.53	1.80	21.00	2.20	4.10	8.87	2.23	3.90	10.70	8.20
Standard Deviation	1.45	1.19	.85	.90	1.08	1.44	.62	1.45	.59	4.88	1.99	3.31	.60	.59	1.87	1.75	1.76	5.56	4.88
F (Groups I, II, and III)	449.32**	7.24**	20.43**	27.56**	23.79**	5.31**	25.04**	13.60**	29.34**	31.71**	48.60**	14.11**	4.44*	.36	15.19**	5.91*	1.28	3.44*	21.14**
t For Groups I and II	24.68**	.43	7.69**	2.86**	6.86**	3.15**	1.79	5.96**	3.67**	2.18*	8.25**	2.71**	1.20	.96	3.87**	2.60**	2.24*	2.40*	5.09**
t For Groups I and III	24.17**	3.74**	10.74**	7.46**	2.06*	.60	7.05**	16.53**	5.59**	7.56**	7.97**	4.87**	1.77	.58	4.83**	4.26**	.46	1.81	4.71**
t For Groups II and III	.45	2.85**	6.94**	3.98**	4.31**	2.65**	4.56**	9.09**	5.51**	3.68**	.16	2.20*	1.57	.33	.83	1.43	1.54	.52	.82
Bartlett's Chi-square (Groups I, II, and III)	57.81**	4.64	17.77**	15.20**	4.35	19.17**	24.05**	3.62	10.76**	8.67*	8.75*	10.02**	20.60**	24.15**	17.18**	20.77**	18.01**	7.05*	17.07**
F—Ratio for Groups I and II	2.01**	1.59	1.38	1.87*	1.36	3.28**	1.07	1.01	1.10	1.04	1.92*	2.01*	7.04**	1.48	1.17	1.99*	1.32	1.83*	3.38**
F—Ratio for Groups I and III	28.01**	2.45**	3.26**	1.58	1.15	1.38	4.90**	1.08	3.70**	2.16*	1.90*	2.02*	2.86**	4.08**	3.30**	4.35**	2.90**	1.37	2.77**
F—Ratio for Groups II and III	13.91**	1.50	4.52**	2.87**	1.18	2.39**	4.58**	1.55	3.45**	2.25**	1.01	1.00	2.46**	6.04**	2.76**	2.19	2.18*	1.33	1.22

[1] Measured in units from 1 to 3, inclusive.
[2] Measured in units from 1 to 6, inclusive.
[3] Measured in units from 1 to 9, inclusive.
[4] Measured in units from 1 to 15, inclusive.
[5] Measured in units from 1 to 26, inclusive.
[6] Measured in units from 1 to 48, inclusive.
* Significant at .05 level of confidence.
** Significant at .01 level of confidence.

suggests that old age is significantly related to these 2 aspects of the self-concept.

The comparison of the aged institutionalized group and the group of young adults revealed significant differences on all but 5 test measures. Religion was the 1 additional area in which no difference occurred in the attitude of these 2 groups.

No differences were found in the aged independent and the young adult groups' views of social maturity, number of contradictory views, W.A.Y. affect and categories, or measures obtained from the Picture Series. Although it would seem that a group from high-economic background would view their ability to contribute socially in a more positive fashion than a group of low-economic status, no such difference was found. This is an additional suggestion that although a group from high-economic status may reach a higher level of social competence, their view of competence is lowered with the infirmities of age. Since significantly fewer differences occurred in the measured aspects of the self-concept for these 2 groups, it was also suggested that as the psychologic effects of age set in the attitudes toward the self of an aged high-economic group become more like those of individuals from more limited circumstances. Since no difference occurred in the contradictory views reported by these 2 groups and both groups reported fewer contradictory views than did the aged institutionalized group, it was suggested that the views of the aged institutionalized group were more poorly organized.

Variances, as tested by Bartlett's chi-square and *F*-ratio tests of homogeneity, also were significantly different on most of the test measures. A significant trend in terms of size and direction of variance was observed which was worthy of note. In general the variances of the 2 aged groups were significantly larger than for the young group. There was evidence, then, of more individual variability within the aged groups in feeling of self-worth than occurred for the group of young adults. This finding supports the clinical observation that there is considerable variation in the degree to which an individual succumbs to the effects of age. In addition, it shows that while tests which have been standardized on an aged population show wide variance with these populations, this variance is reduced when the test is applied to younger subjects. Similar findings have been reported when tests standardized on young adults have been used with aged populations. The implications of this in terms of the longitudinal studies which have been proposed should not be ignored, since it seems unlikely that tests which could be used with young adults would have the same discriminatory value as the population matured.

Statistical Comparison of the 15 Environmental Variables with the 18 Test Measures of Aspects of the Self-Concept

Pearson product-moment correlations were calculated between the 2 types of measurement for each of the 3 groups. These results are reported in table 3. As will be seen from the table, the significant relationships varied from group to group. Of the possible 810 correlations which were computed for the 3 groups, 130 emerged with statistical significance at the .05 level of confidence. Of these 130, 59 were significant at the .01 level of confidence. This number of significant relationships, according to Wilkinson (19), is considerably above that which would occur on the basis of chance alone.

In order to clarify the meaning of the relationships between the environmental variables and the test measures of aspects of the self-concept it seems most economical to discuss them first in terms of the significant relationships within each group and then on the basis of the comparisons which could be made between the relationships established for the 3 groups. Within the aged institutionalized group the environmental variables of mood of life, present mood, Kent E.G.Y. score, and educational level were the variables which were most significantly related to positive statements about the self reported on the 18 self-concept measures. Therefore, those individuals within the institutional en-

TABLE 3.

CORRELATIONS BETWEEN ENVIRONMENTAL VARIABLES AND ASPECTS OF THE SELF-CONCEPT FOR GROUP I, 60 AGED, LOW-ECONOMIC, INSTITUTIONALIZED SUBJECTS; GROUP II, 30 AGED, HIGH-ECONOMIC, NON-INSTITUTIONALIZED SUBJECTS; AND GROUP III, 30 YOUNG, LOW-ECONOMIC, NON-INSTITUTIONALIZED SUBJECTS.

	Subject's Social Maturity Rating	Chicago Attitude Scale Health	Friends	Work	Economic Security	Religion	Feeling of Usefulness	Happiness	Family	Total Score	Number of Contradictions	Self-Concept Questionnaire	W.A.Y. Categories	W.A.Y. Affect	Picture Series Negative Stories	Neutral Stories	Positive Stories	Longevity Score
GROUP I																		
Age	−.18	.22*	.04	.01	.03	.11	.17**	.31**	.20	.22*	.09	.18	.09	.15	−.11	.06	.06	−.01
Attitude Toward Aging	.00	.28*	.19	.15	−.23	.03	.35**	.47**	−.01	.27*	−.09	.24	.09	.12	−.02	.07	−.01	.12
Length of Residence	.05	.12	.09	−.08	.11	.24	−.02	.09	−.08	.05	.05	−.14	.18	.09	−.09	.02	.31**	−.05
Health Judgment	.02	.28*	.13	.09	−.17	.08	.12	.13	−.04	.15	−.06	.12	.00	−.11	−.02	.00	.01	.08
Family Success	.03	.07	.06	.10	.27*	.12	−.06	.19	.35**	.18	−.05	.14	.17	.26*	−.08	.10	−.03	.07
Social Success	.11	−.07	−.04	−.03	.15	−.03	.00	.07	.24	.04	.01	.12	.13	.23	.30*	.31*	−.05	−.07
Years Since Employment	.00	.04	.09	.04	.02	−.01	.09	.28*	−.05	.10	.12	−.08	.01	.13	.11	.22	−.15	−.13
Occupational Success	.07	.22	.20	−.05	.22	.08	.12	.18	.14	.22	−.19	.33**	−.01	.09	−.21	.20	−.01	.11
Religious Importance	.18*	−.11	.02	.00	.21	.14	.10	.00	.20	.08	.02	−.05	.13	.21	.06	−.07	.01	.03
Number of Activities	.39**	.00	.15	.12	.08	−.11	.10	.02	−.15	.03	−.19	.10	−.00	−.14	.28*	−.18	.08	.20
Mood of Life	−.07	.30**	.25**	−.03	.22	.03	.21**	.41**	.17	.31**	−.04	.33**	.09	.26*	.15	.01	−.17	−.07
Present Mood	.10	.39**	.40**	.34**	.23*	−.04	.47**	.64**	.21	.52**	−.04	.45**	.08	.05	.08	.17**	.12	−.04
Kent EGY	.27**	.07	.14	.14	−.08	−.01	.16	.21*	.10	.15	−.20	.28*	.29*	−.06	.26*	−.34**	.13	.28*
Informant's Social Maturity Rating	.68**	−.09	.11	.02	−.01	−.10	.01	.01	.04	.03	−.19	.15	.09	−.16	−.19	−.14	−.05	.18
Educational Level	.36**	−.02	−.38**	.39**	−.13	−.22	.67**	.32**	−.06	.12	.07	−.03	.02	.22	.17	.32**	−.27*	.17

TABLE 3.—(Continued)

GROUP II																		
Age	−.12	.25	−.17	.04	.17	.00	.06	.19	−.11	.09	−.02	.27	−.37*	−.03	.01	.13	−.15	−.06

TABLE 3.—(Continued)

GROUP II																	
Age	−.12	.25*	−.17	.04	.17	.00	.06	.19	−.11	.09	−.02	.27	−.37*	−.03	.01	.13	−.15	−.06
Attitude Toward Aging	.12	.60**	.00	.44**	.33	.09	.52**	.31	.35	.46**	.38*	.85**	.38*	.10	−.19	.03	−.09	.49**
Length of Residence	.03	−.12	.03	.04	.13	.11	.28	.07	−.03	.11	.16	.09	−.13	.04	−.18	.08	.13	−.13
Health Judgment	.10	.25	−.29	−.08	.28	.24	.22	−.04	−.02	.11	.06	.17	.09	−.11	−.21	.13	.11	−.20
Family Success	.07	−.04	.29*	−.09	.22	.16	.16	.35	.30	.32	.24*	.30*	.05	−.03	.09	−.04	−.09	.41**
Social Success	.01	−.06	.41**	.03	.25	.04	.01	.17	.25	.23	.38	.38	.03	.07	.03	.03	−.11	.19
Years Since Employment	−.24	.25	−.68**	−.22	.16	−.33	−.36	−.07	−.16	−.34	−.07**	−.02	−.27	.17	.35*	.33**	−.20	−.19
Occupational Success	.29	.38	.09	.24	.33	.08**	.14	.12	−.16	.19	.56**	.30	.35	.05	−.43*	.49**	−.03	−.17
Religious Importance	.02	−.17	.17	−.27	−.08	.66**	−.03	.04	−.21	.17	.21	.10**	−.28	.00	.32	−.03	−.34	.19
Number of Activities	.05	.06	.04	−.01	.26	.32	.15	.28*	.12	.33	−.30	.51**	.18	−.12	−.12	−.08	.24	−.11
Mood of Life	.12	.13	.25*	−.05	.01	.23	.12	.39*	.30*	.32**	.15*	.47**	.07	.17*	.24	−.09	−.21	.11
Present Mood	.26	−.33	.37*	−.06	.18	.27	.28	.42*	.36	.52**	.37*	.49**	.41*	.36	.03	.10**	−.15	.00**
Kent EGY	.32**	.05	−.05	.10**	.22	.10	.21**	−.04	−.01	.14**	.45**	.20**	.19**	−.03	.33	−.46**	.10	.53**
Informant's Social Maturity Rating	.54**	.26	.28	.56**	.13**	.20	.51**	.26	.02	.49**	.48**	.38**	.46**	−.30	.17	−.33*	.15	.21
Educational Level	.35	.13	−.19	.07	.52**	−.04	.21	.01	−.22	.10	−.34	.14	−.08	−.16	.17	−.45*	.27	.19
GROUP III																		
Age	.17	−.05	.03**	−.29	−.28	.02	.23	.10	.05	−.01	−.10	−.12	.11	.30	.02	.22	−.24	−.18
Attitude Toward Aging	−.15	.34	.48**	−.25	.19	.29	−.15	.25	.00	.34	−.34	.03*	.17	.35	−.12	−.11	.23	.40*
Length of Residence	.08	.12**	.00	.10	.23**	−.26	.06	−.20	.00	−.03	−.20	−.43*	.03	−.05	.16	.16	−.32	−.12
Health Judgment	.21*	.65**	−.03**	.23	.57*	.00	.12**	.01	.08*	.35**	−.17**	.13	−.05	−.16	−.12	.10	.02	−.23
Family Success	.36	.48**	.65*	.00	.41	.21	.46**	.31	.44**	.59**	.53**	.32	.02	.04	.19	−.23	.02	.12
Social Success	.32	.17	.37	.03	.28	−.11	.23	.13	.51**	.19	−.03	.26	−.03	.08	.11	−.35	.32	−.04
Years Since Employment	.03	−.07	−.18*	.24*	.03*	.12	.10	.10	.06	.07*	−.11*	.08	−.10	.05	.02	−.06	.03	−.01
Occupational Success	.05**	.26*	.37	.42	.42**	.19	.07*	.03	.08	.38**	.36*	.16	−.15	−.08	−.26	.15	.13	.10
Religious Importance	.50**	.43*	.16	−.05	.55**	.19	.40	.35	.09*	.47**	.36	−.08	.31	−.05	−.20	.27	−.06	−.27*
Number of Activities	.17*	.40**	.16**	.07	.55**	−.06	.29*	.07	.39**	.35*	−.13	.23	.06	−.07	−.12	−.07	.20	.36**
Mood of Life	−.36	.33	.58**	−.14	−.35	.04	.37*	.10	.55**	.42*	−.32	.32*	.02	.04	.13	.33	.20	.05
Present Mood[1]																		
Kent EGY	.63**	.10*	.26	.27	.26*	−.04	.44**	.50**	.20	.40*	−.22	.37*	−.02	−.28	.05	−.02	−.03	.45*
Informant's Social Maturity Rating	.77**	.36*	−.14	.17	.36*	−.15	.31	.14*	.11	.23	−.10	.15*	.19	−.05	.10	.07	−.15	.26*
Educational Level	.34	.13	−.07	.25	.35	−.14	.25	.42*	.07	.27	−.17	.36*	.01	−.15	−.06	−.01	.07	.38**

* Significant at .05 level of Confidence.
** Significant at .01 level of Confidence.

[1] In this group "Present Mood" showed no variance. Accordingly all correlations are indeterminate.

vironment who were judged to have had a happy life and to be happy at the present time reported significantly more positive attitudes of self-worth. Individuals who were still able to maintain some intellectual interest, suggested by a high score on the Kent E.G.Y. Scale, seemed better able to maintain a positive view of their self-worth. High educational level also was a variable significantly related to positive feelings of self-worth.

Within the aged independent group similar relationships were noted. Attitude toward aging, present mood, and informant's social maturity rating were the variables which were most significantly related to positive attitudes toward the self. Those individuals within this group, then, who were judged to feel younger than their present age and to be happy at the present time also reported more positive feelings of self-worth. Of particular importance was the evidence that the individuals within this group who were judged to be functioning socially at the highest level also reported more positive attitudes toward the self.

In striking contrast were the environmental variables which were significantly related to positive attitudes toward the self within the group of young adults. The variables of family success, occupational success, religious importance, mood of life, and Kent E.G.Y. score were the variables which were shown to have a positive relationship with values of self-worth. Those individuals, then, who were judged most positively in the roles of family and occupational success and religious importance also reported significantly more positive attitudes toward the self.

Comparison of the significant relationships between the environmental variables and test measures for the 2 aged groups showed that the positive, subjective judgments of attitude toward aging, mood of life, and present mood were the variables which were significantly related to positive attitudes toward the self within these groups despite widely different living conditions. In addition, although the informant's judgment of the social maturity of the subject had little or no relationship to the attitudes toward the self within the institutionalized group, a high score on this variable was strongly related to positive attitudes toward the self in the independent group. This undoubtedly reflected the critical reduction in social functioning produced by the limitations of an institutionalized environment and suggested that in a normal, give-and-take, independent existence the level at which an aged individual is able to function socially is a significant factor in his view of his own self-worth. Furthermore, since this variable had much less relationship to the attitudes toward the self of the young group it seems that ability to function adequately socially becomes a factor of greater importance to the self-conceptualization of an aged group.

Within the institutionalized group, intellectual and educational levels were important factors which were related to positive aspects of the self-concept. This suggests that in an institutional environment where other opportunities for interaction are cut off, intellectual activities contribute to more positive attitudes toward the self.

This analysis showed that a happy, subjective attitude toward present mode of living was most significantly related to positive aspects of the self-concept for 2 aged populations. On the other hand, the posited variables reflecting the success and achievements in everyday life are significantly related to the attitudes of young adults toward themselves.

Reference to table 3 shows that chronologic age *per se* had no relationship, other than that which would be expected by chance, to the attitudes toward the self for the 3 groups. It will be remembered, however, that, in the comparison of the mean attitudes of the 3 groups, the young adult group reported significantly more positive attitudes of self-worth (table 2). Therefore, it would seem that age is a variable which is significantly related to positive attitudes toward the self only when the age range is marked, i.e., young versus old.

When considering the test measurements

which were most frequently related to the posited variables, it was observed that fewer of the test measures were related to the posited variables within the younger group. This suggests that the test battery designed for use with an aged population was not sufficiently sensitive to investigate the self-concept of a group of young adults. The W.A.Y. categories and the number of contradictory views, the 2 measures of the organized-to-disorganized continuum of the self-concept, were not related to the environmental variables within the institutionalized group but were related to the posited variables within the aged independent and the young adult groups. Although it is possible that these measures of degree of organization were not sensitive enough to uncover the nuances of this aspect of conceptualization, there is a suggestion that the attitudes toward the self are more poorly organized within the aged institutionalized group.

Discussion

In integrating the results of this study into a composite picture of the personality functioning of the aged, it is important to note that the findings which emerged from the first statistical analysis were verified and enlarged upon by each subsequent analysis. For example, the comparison of the way the 3 groups were judged by the informants showed significantly different means and variances, emphasizing the widely divergent backgrounds of the groups. Of significance, then, was the evidence that both aged groups were judged to have a more negative present mood than the younger group. Also, despite assumed similar backgrounds, the greatest difference in judgment occurred between the aged institutionalized and the young adult groups, showing the combined effect of age and institutional living on present functioning levels. Finally, although a group of high-economic status would be expected to have attained higher levels of intellectual functioning and social maturity than a group from low-economic background, no such difference was found. This suggests that after individuals reach a peak level of functioning, their abilities fall off in varying degrees.

On questionnaire-type items, the aged institutionalized group reported the least positive view of self-worth, the aged independent group a somewhat more positive view, and the group of young adults the most positive view. The 2 aged groups, despite widely divergent backgrounds, showed no difference in attitudes toward health and feeling of usefulness, being somewhat negative in both. The attitudes of self-worth of the aged, high-economic, independent group resembled those of the young, low-economic group more than did those of the aged, low-economic, institutionalized group.

Seemingly contradictory was the evidence that the aged institutionalized group report significantly more positive attitudes in response to projective type of stimuli than the aged independent and the young adult groups. Since the aged institutionalized group is surrounded daily by the results of the aging process, it seems possible that they are less threatened by problems encountered in the daily life of aged individuals.

Analysis of homogeneity of variance added further information concerning the developmental features of attitudes of self-worth. The 2 aged groups showed similar, significantly greater variability of response than did the group of young adults. Therefore, not only do older individuals view themselves generally in a more negative fashion, but there is greater inter-individual variability in these attitudes. It was noted also that a test standardized on an aged population produced wide variability of response with aged groups, but this variability was markedly reduced when the test was used with younger adults. A test suitable for use with individuals in later maturity loses much of its significance when applied to younger groups. The problem of establishing tests which might be usable throughout the age continuum seems worthy of investigation.

The major concern of the study was the comparison of the environmental variables to aspects of the self-concept. The analyses

of these data showed significant relationships between the two types of measurements for each of the 3 groups. In both aged groups the individuals who were judged to feel younger than their stated age, to have had a happy life, and to be happy at the present time reported significantly more positive attitudes toward the self. Therefore, judgments concerning the present mode of living were related to positive aspects of the self-concept for the 2 aged groups. On the other hand, in the group of young adults the individuals who were judged to be most successful in the roles of family, occupational success, and religious importance reported the most positive views of self-worth. Within the group of young adults, then, the environmental variables suggesting success in roles in life were significantly related to positive attitudes toward the self.

Those findings suggest that since a group of young adults is actively engaged in productive work, the successes they achieve are significantly related to their view of self-worth, while the self-worth of aged groups is significantly related to a happy outlook on life in general.

Although the informant's judgment of social maturity had little or no relationship to the attitudes toward the self within the aged institutionalized and the young adult groups, a high judgment was related to positive attitudes toward the self in the aged independent group. This suggests that ability to function adequately socially in a normal, give-and-take, independent existence is important to the positive self-conceptualization of aged individuals. On the other hand, since high intelligence was more frequently related to positive attitudes toward the self within the aged institutionalized group, it would seem that in the more limited environment the individuals who maintain intellectual interests view themselves more positively.

Interpretations of the meaning of positive-to-negative aspects of the self-concept have been presented. Little or no mention has been made of the organized-to-disorganized continuum. A significantly greater number of contradictory views occurred among the aged institutionalized group than in the other groups. It was also observed that the 2 measures of organization, the W.A.Y. categories and the number of contradictory views, were not significantly related to the environmental variables within the aged institutionalized group but were related to certain variables within the other 2 groups. The trend of more poorly organized self-conceptualization within the aged institutionalized group appears but is never clearly substantiated. The inconclusiveness of the findings of the organized-to-disorganized continuum seemed to be due to both the difficulty in defining and measuring the continuum and to the fact that only 2 measures were included in the test battery.

Summary

Two groups of aged individuals, one institutionalized and one not institutionalized, and a group of young adults were studied to evaluate the relationship of certain environmental variables to measured aspects of the self-concept. A group of 60 indigent, institutionalized subjects above age 55 was compared with a group of 30 subjects of middle-class status above age 60, who were still able to maintain an independent existence. A third group of 30 young adults also was studied, which allowed a comparison of changes in self-conceptualization of 2 different age groups. These findings show that:

1. An aged institutionalized group views its self-worth in a more negative fashion than does an aged independent group, and this group, in turn, views its self-worth in a more negative fashion than does a group of young adults.

2. Despite marked differences in living conditions, no difference was found in the 2 aged groups' negative attitudes toward present state of happiness and present ability to contribute. Therefore, old age is related to some negative feelings of self-worth.

3. Although the 2 aged groups were found to be more negative in their view of self-worth than a group of young adults, signifi-

antly greater inter-individual variability occurs in their reports of their positive-to-negative attitudes. Therefore, the degree to which an individual succumbs to the effects of old age varies markedly.

4. No difference was found between the aged, high-economic and the young, low-economic groups with regard to social maturity and intellectual functioning.

5. Environmental variables reflecting positive judgments toward present mode of life were significantly related to positive attitudes toward the self in the 2 aged populations; while successes in roles in which the individual actively engaged each day were significantly related to the positive aspects of the self-concept of a group of young adults.

6. Present level of social maturity as judged by informants was a variable significantly related to attitudes toward the self in an aged independent group.

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AGE AND THE PROBLEMS OF PROFESSIONAL TRUCK DRIVERS IN HIGHWAY TRANSPORTATION[1]

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THE increasing age of our population is a matter of common knowledge and increasing social concern. It is reflected in social and political changes and also in industrial policy-making and planning. This report will present some data and interpretation concerning the age characteristics of workers in the highway transportation industry with the purpose of pointing out the significance of these considerations for personnel management in this field and also for broader problems in the vocational adjustment of workers of all ages.

As the average age of the population increases, any industry, and especially one with potential growth possibilities, will be faced with sharper competition for the proportionately smaller number of young men available in the labor market of the nation. This competition can be met only by higher financial returns to the worker and better over-all working conditions. The place where the labor market will be freer will be, of course, in the older part of the population. In spite of current pressures for early retirement, the trucking industry, like all others, will find it increasingly necessary in the years ahead to find ways to use more older men. This can be accomplished by more careful initial selection in terms of relevant abilities, by placing older workers in jobs or assigning them tasks where age-related deficiencies will not be a hazard, and by making use, in new ways, of senior employees' accumulated experience and judgment. A study of this general problem as it concerns air transportation has already been carried out by McFarland (19).

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AGE DISTRIBUTION OF SELECTED SAMPLES OF TRUCK DRIVERS

The rapid growth of the highway transport industry is one of the major factors determining the age of the men who drive the vehicles. The number of registered trucks on the nation's highways has almost doubled on the average of once every five years in the last forty years (2). About 8 per cent of wage-earners in the country are in the truck transportation industry (2), which is now second only to agriculture in the number of persons employed.

Data are available from the 1950 Census (30) on the ages of those who claim truck driving as their principal occupation. These data, however, are not in such form as to permit descriptions of the age characteristics of the truck drivers in the trucking industry. The most relevant age tabulation in the Census combines truck and tractor operators with delivery men and route men. About 15 per cent of the total are in the latter two categories but the number of tractor operators included cannot be determined. The tabulation is based, moreover, on the Census respondent's statement of occupation and there is no way of telling whether such an individual is in business for himself, whether he leases his time and his vehicle to a trucking firm, or whether he works for a mining, manufacturing, wholesaling, or other enterprise. Nor is it possible to determine what proportion of his time is spent at truck driving, aside from the fact that it is his principal occupation. Further difficulties involved in interpreting statistics about highway transportation are illustrated by the fact that although there were 6.1 million privately-owned non-farm trucks registered in the U.S.

in 1950 (2), the Census tallies only 1.5 million truck and tractor operators and delivery and route men. The indicated ratio of less than 0.21 truck driver per non-farm truck is far from the accepted figure of the trucking industry, which is 0.8 driver per non-farm truck. Also, the 1950 Census gives a total of 630,000 in the "trucking service" industry but the trucking industry itself claims 5.2 million drivers and employees of trucking firms (2). These discrepancies between the statistics of the Census and of the industry, and the problems of definition and classification which they raise, make it desirable to collect further data on defined samples of truck drivers if their characteristics as related to age are to be analyzed.

In connection with the present study, a beginning has been made in this direction and age data have been collected on a number of samples of truck drivers which may give a useful notion of their age composition and of some of the factors influencing it. Figure 1A shows the ages of the drivers of a long-haul trucking firm which carries small parcels. This company is engaged in interurban and interstate transport, picking up and delivering small consignments. The median age of the drivers is 36, with the middle half of the group covering the 10-year range from 31 to 40 years, although the total age range for the group is 42 years, from 21 to 63.

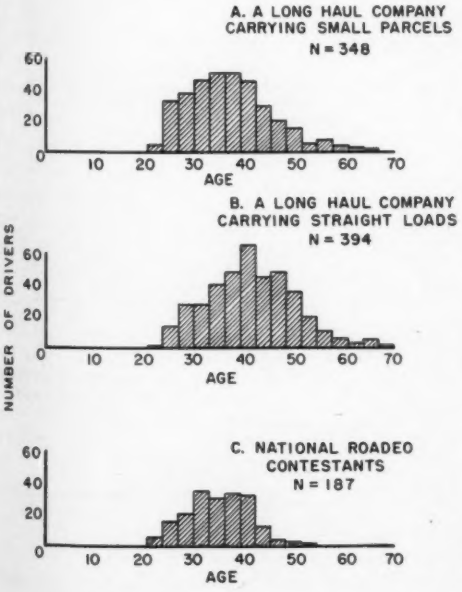

FIG. 1. Ages of 3 Groups of Truck Drivers.

In figure 1B are plotted the ages of the drivers of another long-haul company which carries straight loads. This work usually involves transportation of single consignments, carried from a terminal or shipper to another terminal or a receiver, where the loading and unloading are most often done by the dock crew or with mechanical aids. The median age of this group is 40 with the middle 50 per cent in the eleven-year range from 35 to 46. The whole range, however, is about the same as that of the first group, 43 years, from 23 to 66. The second group is, as a whole, about four years older than the other, a difference which is probably explained in large part by the nature of the physical work required of the straight-load driver as compared with that of the small-parcel driver. The latter will usually lift and carry 10,000 to 30,000 lbs. in a day's run and there is reason to suppose some significant selection has taken place, whereby younger men with greater strength are more likely to be in the employ of the company represented in figure 1A.

Of interest for comparison with the foregoing groups are the "Roadeo" contestants presented in figure 1C. These men were selected on the basis of local and state competition to take part in the national finals. Selection involved knowledge of traffic rules and safety procedures, accident-free performance on the highway, and skill in handling vehicles in parking and slow-driving situations. This sample included contestants for three successive years. The highly selected drivers in the group cover a narrower age range than the other groups, being especially lacking in men over 45.

TABLE 1. AGE AND EXPERIENCE OF MOTOR TRUCK OPERATORS
Reported years of experience of a sample of motor truck operators at the time of new employment, the operators being classified by age.

Age Group	N	Years of Experience			
		Mean	Median	S. D.	Range
21–25	86	5.0	4.9	1.8	1–9
26–30	118	8.8	8.9	3.0	1–15
31–35	83	11.0	11.4	4.3	1–21
36–40	54	15.1	15.2	4.9	2–23
41–45	20	19.5	21.5	7.0	2–26
46–60	17	26.1	25.2	7.4	6–33

THE RELATION OF AGE TO EXPERIENCE IN TRUCK DRIVERS

Studies of the work histories of truck drivers show there is a strong tendency for them to stay in the occupation. In addition, however, the occupation has developed so rapidly that most of the men in it have spent the greater part of their working lives at it. The data in table 1 were collected on employees within the first month of service on new jobs in several New England trucking firms. These data show a regular increase in experience with age. As a group these men have spent more than 70 per cent of their lives since they were 17 years old as truck drivers but the wide range of experience in each age group is noteworthy. It may be inferred from the table that several of these men earned wages driving a truck when they were 15 or 16 years old. If this seems surprising and illegal, it should be remembered that well-developed adolescents of the same ages have many times been able to enlist in the armed services, in spite of the much more careful screening and examining procedures used under those circumstances.

AGE RELATED TO EMPLOYMENT AND SEPARATION

The data in figure 2A and 2B were secured from 54 trucking companies during a period of several years and have been combined to show the ages of all their drivers who were employed or separated during the period. These data do not include, therefore, any employees who were on the job throughout the period. The net increase in employees in these companies, which amounted to 1,970 men, may mask some of the similarities between the two sets of figures. The distributions are nearly the same shape and have the same average, 30 years. Both have peaks in the late twenties and taper off gradually in the thirties and forties. A little

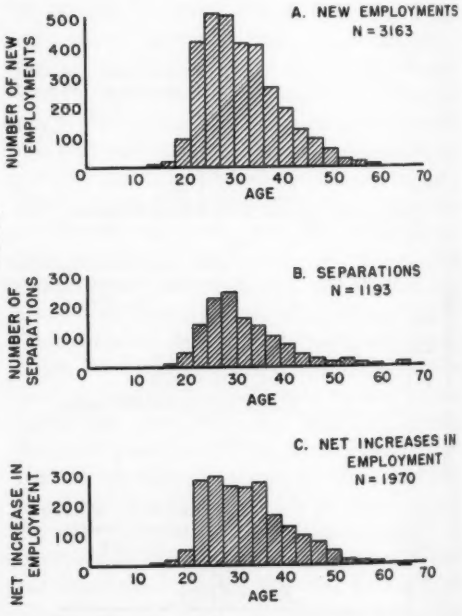

FIG. 2. Ages of truck drivers at the time of new employment and at the time of separation from employment.

over 2 per cent of the cases represented in each of the curves is in the age range of 50 years and over.

The difference between these two curves indicates the net additions in the truck driving force of these 54 companies. This difference is plotted in figure 2C, which can be analyzed to show that 70 per cent of the net increase is rather evenly distributed over the 15-year age range from 21 to 35. Nevertheless, 12.5 per cent (1 out of 8) of the net new drivers are 41 or over and 1.5 per cent are over 50. Considered in this way the labor turnover of the trucking industry differs markedly from that of another transportation industry—the railroads—where new employment is almost always in the younger years and unreplaced separation characterizes the older ages.

Age Related to Learning Job Skills

Figure 3 presents data to show the age at which a sample of truck drivers learned to drive a car, a truck, and a tractor-semitrailer combination. Half of these men could drive a car before they were 18 and only 1 in 14 learned after he was 21. The distribution covers a wide range, however, from 10 to 41 years. These drivers usually mastered the truck a few years after learning to drive a car. The median age is 20, the last 7 per cent learned after they were 27, and the distribution is again wide, from 12 to 40 years. About 5/6 of these drivers have learned to drive a tractor-semitrailer combination. The median age of learning is 24 and the last 7 per cent learned when they were 35 or older. The range of ages in this distribution, from 14 to 55, is about as wide as the age ranges in total driver groups shown in figure 1.

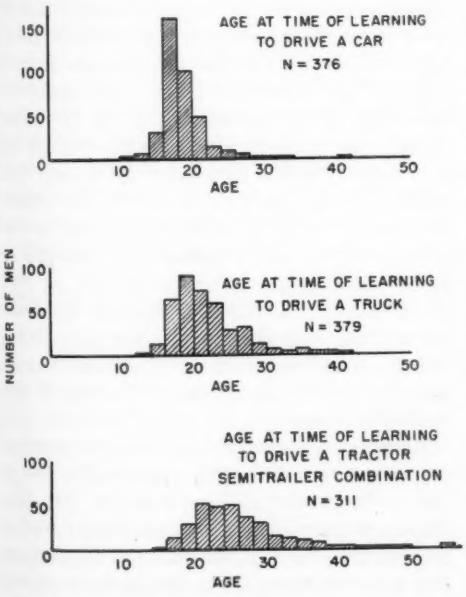

FIG. 3. Age at which truck drivers learned to drive. Reported age at which 379 truck and tractor-semitrailer operators learned to drive a car, a truck, and a tractor-semitrailer.

There are several implications of the data in figure 3. First, mastery of driving skill is almost always in the order car-truck-semitrailer. In this sample there were only 4 exceptions: 3 young men who had done all their previous driving in farm trucks and 1 who had driven a truck before he drove a car. Second, these skills can apparently be mastered to an acceptable level of performance in a few years. Twenty-six of the 311 semitrailer drivers presumably held such a job at the age of 18 or less, and 25 per cent of them before they were 21, the legal ICC minimum age. Below that age such young men could legally drive in intra-state commerce. Third, although most truck drivers learn young, there seems to be no upper age barrier to the mastery of the necessary skills. The oldest 10 men to learn to drive a semitrailer did so in the age range from 38 to 55. This range is the same as that which includes the oldest 1/3 to 1/2 of the working truck drivers according to the data of figure 1. It is also the range which includes about 20 per cent of the net new employees, both truck and semitrailer drivers, represented in figure 2C.

Age and Physiologic Competence

Truck driving is frequently considered a young man's occupation and there is con-

siderable physiologic and psychologic justification for that belief. It should be noted however, that part of the apparent youth of truck drivers stems from the rapid growth of the industry. A rapidly expanding occupation will tend to draw its new employees from the age levels which have not yet had time to get too much training and experience or other sorts of investment in another kind of work, as figure 2 shows.

There are other physiologic reasons why youth is characteristic of truck driving. Probably most important is the factor of muscular strength. There are good cross-sectional data (9) supported by fairly satisfactory physiologic interpretation (27) to show that even if he continues to exercise, a man's muscles decrease in their possible output with age. There are wide variations in strength among individuals of any age and many men 55 years of age will be stronger than most men at 25, but the trend is downward. Men also differ in the skill with which they use their strength so that a weaker (older) man may learn to do a certain lifting or carrying task with less output by reason of his skill. These compensations cannot be expected to make up entirely for the decreasing strength of age and it has been observed that the older a man is, the more likely he is to leave truck driving as a profession, either voluntarily or involuntarily. This is the interpretation which was given for the differences in the age distributions in figures 1A and 1B. The relative absence of younger men in the company of 1B may be due to personnel policy, turnover rate, or other factors peculiar to that company, but the relative absence of men over 40 in the distribution of figure 1A is probably to be explained by the difficulty older men have in doing the job required of them in small-parcel hauling.

Another physiologic change in the human organism as it grows older is its reduced ability to maintain many sorts of chemical and physical balance in the internal environment of the body—the process called homeostasis. These adjustment mechanisms include such processes as the maintenance of body temperature, control of blood flow to the various parts of the body, maintenance of the chemical constituents of the body fluids, and all the mechanisms whereby we respond to conditions of stress. The homeostatic processes have this characteristic in common, that they become less efficient with increasing age (27). The body becomes less able to compensate for any extreme conditions it may be required to meet and a defect in the operation of any one homeostatic system becomes more likely to produce some general breakdown or incapacity of the whole organism.

Age and Sensory Function

Some sensory changes with age, such as those in taste and smell, are of small functional significance in daily life and in most occupations. On the other hand, reductions in visual and auditory capacities can often be critical. The refractive capacity of the eye is reduced with age but this is correctable for most purposes by glasses. Not correctable, however, are the decline in maximum acuity (10) and the elevation in the dark adapted threshold. Several studies (4, 5, 12, 20) have shown that there is a progressive change in the dark-adapted threshold from age 20, which becomes more rapid in the later years. Probably correlated with the change in the dark-adapted light threshold are changes in other abilities involving perception at low illuminations which would increase the hazard of older men driving at night (1). These changes might mean 25 or 50 yards delay in becoming aware of objects at the limit of the headlight beam.

Another well-recognized loss in sensory capacity associated with aging is the rise in the auditory thresholds (3, 6, 28, 31, 34). This is measurable during adolescence and is progressive throughout life. The earliest and greatest losses are in the high-frequency range but by middle life there are usually losses in the middle range most used in the comprehension of speech. Such losses in a truck or bus driver might reduce his efficiency

in personal relations and lessen his ability to perceive abnormal noises from his equipment. On the other hand there are data from aircraft pilots (29) which indicate that men who show significant losses in hearing acuity when tested under quiet conditions show less, or no loss, as compared with normal hearing pilots when tested under the loud noise conditions of the cockpit. A similar situation may characterize the hearing performance of truck drivers in a cab. Current approaches to the testing of hearing emphasize the evaluation of hearing in normal communication and perception situations rather than the laboratory type of threshold measurement (6, 7, 19). When more extensive measurements of these operational types are available, it may appear, as the data on aircraft pilots suggest, that the most valuable classifications of hearing deficiency will not follow closely the findings from the usual audiometer measurements. Also, most hearing losses can be somewhat compensated for by properly constructed hearing aids. The use of a hearing aid is still regarded in the American culture as more of a negative cosmetic quantity than are glasses, so that personal adjustment problems may be involved in their use. On the other hand the greater usefulness of more carefully prescribed and designed instruments may be able to offset in value the mild social stigma currently involved in the use of a hearing aid.

Age and Performance Characteristics

A number of studies on aging (8, 18, 20, 21) have shown that, on the average, the years after 30 bring a decline in the ability to perform motor acts with the hands or feet when both high speed and high accuracy are required. The decline is gradual and, as with strength, sensory function, and all other abilities, there is much overlapping between age groups. The significance of this decline for the truck driver is questionable both by reason of these wide individual differences at every age and because there are other ways in which the purposes of driving can be achieved beside quick and sure reactions. A young driver may handle an emergency because he can lift his foot from the accelerator and apply brake pressure a quarter-or a half-second faster than an older man, but the older man may handle the same situation as successfully by beginning a defensive maneuver three seconds earlier, before the situation becomes critical. Wisdom, judgment, caution, and such overall driving characteristics may compensate for, or make less important, the losses in speed and precision which go with age. This compensation is probably not complete, however, in view of the types of emergency situation which drivers have to face. Furthermore, the awareness of many drivers that they *are* slower and less able to meet a crisis than they once were, even when their actual loss in ability is minor, reflects a disability of practical importance. The anxiety accompanying such an awareness may make a man less capable of good judgment in all sorts of situation. Observation of truck drivers on the road indicates that older drivers frequently compensate for their felt reduction in motor capacities by driving at lower speeds. By contrast, however, it has also been noted that many of them verbalize less anxiety about being behind schedule.

In the last twenty-five years abundant evidence has been gathered to show that many intellectual abilities decline after the middle twenties. The classic studies were done by Miles and Miles (22), Jones and Conrad (14), and Wechsler (32). This decline is most significant in connection with tasks that involve learning and remembering new material, or mastering and using new skills. It is not important in connection with the use of material that has been long known or in situations where plenty of time is allowed for understanding and responding to a new situation (33). Although no data are available on truck and bus drivers directly, these results on other types of subjects would lead us to expect that the older ones would have some greater difficulty in adapting to new equipment or new ways of operating it and to modifications of routes and of procedures. This would be especially true in complex

situations, involving road conditions, traffic, the load, and the power plant, when a degree of judgment is required and a series of operations must be carried out rapidly. Simplifying the operation of a bus or truck would ease the pressure on older men in such situations, in the way that power brakes and power steering can relieve him of the necessity to put forth as much muscular force as old style vehicles require. There is no easy way, however, to simplify the environment around the vehicle.

If one were to compare operators of various transport vehicles with respect to the number and variety of the stimuli which they must perceive and the skill, speed, and judgment required in the response, then the truck or bus driver has a more demanding job than most. Considerably less is required of the railroad engineer. Even the airplane pilot, who may be required to concentrate fully during landings and take-offs, can relax for long periods once he is in the air, and most commercial pilots have an automatic pilot and a co-pilot beside them for relief. The driver on the highway, however, must pay continuous attention to his surroundings and must make continuous readjustments of his controls. We would expect that a smaller and smaller proportion of aging drivers would either be able, or wish, to meet the continuous series of pressing situations to be found in their daily work.

In summary then, the most important change in commercial drivers beyond the age of 50 can be expected in their more limited ability to carry out a series of complex reactions involving memory, judgment, and reasoning within given limits of time.

Age in Relation to Accidents

Recent advances in medicine have made possible our considerable mastery over infectious diseases and we have therefore experienced a marked increase in life expectancy in childhood and adulthood. Control of disease has been one of the major factors involved in the increasing proportion of older people in our country. Since the old-time killers of youth, such as diphtheria, small-pox, and tuberculosis have been brought under increasing control, accidents have become a major cause of death especially in childhood and early adulthood (11). Accidents are the most important cause of death in the age range from 1 to 24; they are second only to heart disease in the age range 25 to 44; they rank fifth in the first year of life and also in the years above 44. When non-fatal accidents to persons and the property-damaging mishaps are added to those resulting in death, we have a source of personal and economic loss which is staggering. Public agencies and industry, in particular, have directed great effort to the discovery and removal of accident causes (for example, 13, especially Appendix II). One suggestion that used to be made more commonly than now is that an older worker was a greater hazard than a younger one simply because he was less able. Insurance statistics and industrial records (15, 16) have shown this to be a mis-statement and have in most instances shown the contrary to be true, when proper statistical control is made of the degree of exposure to accident.

In ordinary pleasure-vehicle driving the age groups under 30 have been found to have the highest accident rate (17, 26) with a gradual decrease toward the older years.

Data are at present limited on the relations between age and frequency of vehicular accidents among truck drivers. One study of 100 drivers of a southern trucking firm showed no correlation between age and frequency of accidents when amount of exposure (hours driven under comparable traffic conditions) was controlled (23). In another study, in which 57 accident-free truck drivers were being compared with 88 accident-repeaters a number of other differences were found, but there was no difference in age (24).

The Interstate Commerce Commission has analyzed some of its data on accidents to show the ages of the drivers of the trucks involved in about 15,000 collision accidents reported to them in 1949 (25). The data, as supplied, tell us nothing about the relation of

age to the causation of accidents because we do not know the age distribution of the total population from which the accident-involved drivers came, nor do we have data on the exposure of the sample or of the population. It is possible to make some inferences, however, about the relation of age to accidents if we compare the age distribution of the driver samples we have with the age distribution of these accident drivers to see whether the proportions in the various age groups are the same. To make such comparisons validly we must assume that exposure to accidents was related to age in the same way in the total Interstate Commerce population, from which the accident-involved drivers came, as in our samples. This is not an unreasonable assumption although there is no way of testing it directly.

Table 2 presents these comparisons for 2 driver samples, separately and combined. In each case there are more accidents than would be expected from the younger age groups and fewer in the older groups, the point of transition being in the early or middle thirties. As is indicated in columns (5), (8), and (11) of the table, the greatest proportion of excess in accidents is in the age group below 25 and the least is in the range beyond 45 years. The significance of the difference between pairs of distributions was tested by χ^2. For this purpose the estimate of the theoretic value for each age group was based on the mean of the two proportions, one from each of the distributions to be compared, in that age group. This was taken, in the case of each pair of distributions, as the best estimate of the true value for that comparison, and this assumption holds even though the two samples differ significantly. The combination of the two samples into one distribution probably gives a better estimate than either of them alone, but each was compared individually to discover whether the result of combination could have been peculiarly determined by one of them.

Although this comparison cannot be considered conclusive, these significant χ^2's support the notion that older truck drivers are safer on the highway than younger ones when all the conditions of operation are equal.

TABLE 2. COMPARISON OF THE AGE DISTRIBUTION OF PROPERTY-CARRYING MOTOR TRANSPORT OPERATORS HAVING ACCIDENTS IN INTERSTATE COMMERCE DURING 1949, WITH THE AGE DISTRIBUTION OF TWO SAMPLES OF OPERATORS.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Age Group	I.C.C. Accident Group; No. of Drivers	I.C.C. Group Reduced to N = 742	Combined Driver Samples (7)+(10)	Ratio of (3) to (4)	I.C.C. Group Reduced to N = 348	Drivers of a long haul, small parcel trucking firm	Ratio of (6) to (7)	I.C.C. Group Reduced to N = 394	Drivers of a long haul straight load trucking firm	Ratio of (9) to (10)
-24	2148	106.5	19	5.61	50.0	17	2.94	56.6	2	28.30
25-29	3806	188.7	96	1.97	88.5	57	1.55	100.2	39	2.57
30-34	3278	162.6	130	1.25	76.3	82	.93	86.3	48	1.80
35-39	2683	133.0	171	.78	62.4	88	.71	70.7	83	.85
40-44	1627	80.7	148	.55	37.8	52	.73	42.8	96	.45
45-49	826	41.0	104	.39	19.2	29	.67	21.8	75	.29
50-54	400	19.8	46	.43	9.3	13	.72	10.5	33	.32
55-59	124	6.3	18	.35	4.5	10	.45	5.1	18	.28
60-	71	3.5	10	.35						
Totals	14,963	742.0	742		348.0	348		394.0	394	
	χ^2		80.85			17.30			66.68	
	d. f.		8			7			7	
	P		$<.001$			<0.02			$<.001$	

Age in Relation to Retirement Programs

Retirement programs have developed rapidly in recent years, sometimes in response to labor union pressure and sometimes on the initiative of management. In a large proportion of cases such programs have proved to be a good thing for both groups. From the point of view of the workers a good retirement program provides security in old age, and from the point of view of the management there is usually secured a higher degree of morale and increased loyalty to the company which should mean more efficient day-to-day production.

So far there are few retirement programs which affect the trucking industry except Social Security—a program which would not provide enough, at current levels of payment, to satisfy most truck drivers. Other programs are under discussion, however, at the present time. Again, the youth of the industry has delayed large concern with this problem. There are too few older men in it because it has attracted young men in their early working lives. If jobs suitable to their capabilities can be found for the aging and more experienced truck drivers in the industry and if retirement programs should be introduced, it might be possible to eliminate some of the turnover suggested by figure 2 and, at the same time, to get a better-spirited, more loyal group of employees.

A frequency chart of age of employees in service in any company, made in a way similar to those in figure 1, may be a useful tool in indicating the time when a retirement program will be needed and the number of drivers who can be expected to be eligible for retirement in any year. Thus plans for the accumulation of financial reserves can be made.

Conclusions and Recommendations

This collection of data on the age characteristics of truck drivers leads to several conclusions and recommendations.

1. As the age composition of our population changes the trucking industry will probably have to select and retain a larger proportion of drivers over 45 than it does now.

2. Groups of employed drivers so far studied have a median age of 35 to 40 and half the drivers in each group will be within 5 or 6 years on either side of this median value. The whole range covered by any sizeable group of drivers runs from below 20 to over 65.

3. Truck drivers have spent most of their working lives in the occupation. Few enter it after 35 and most who are now in it began before they were 25.

4. There is therefore a good correlation between age and experience, in truck drivers.

5. Most truck drivers learn to drive a car in their middle teens and have learned to drive a truck by age 20. Not all truck drivers learn to drive a tractor-semitrailer combination. Those who do range widely at the age of learning, with 24 years as their median.

6. Newly employed drivers are mostly in the range from 21 to 35 years. Although separations are also most frequent in this range, these are the years from which 70 per cent of the net increase in drivers comes.

7. There are several physiologic and psychologic characteristics of the aging process which tend to put a premium on youth in truck driving. Some but not all of them are satisfactorily compensated for by increased experience. Further study is necessary to determine: how critical for truck driving some of these changes are; how to adapt the demands of the job to the older driver; and how to use his capabilities in other occupations in the trucking industry if he is no longer capable of driving.

8. The data relating age to accidents give support to the notion that the older are less likely to have accidents than younger truck drivers.

9. Retirement programs are worthy of study in the trucking industry since they have possibilities of long range benefits both to the companies and the drivers.

Summary

Distributions and other statistics are pre-

sented to show: the ages of defined samples of working truck drivers, the relation of occupational experience of newly employed drivers to age, the ages of truck drivers at employment and at separation from employment, and the age at which learning to drive automotive vehicles occurred. Known physiologic and psychologic changes associated with age are related to the expected decline in vocational competence of older drivers, where this is possible. Available data on truck accidents are interpreted to show that older drivers are less likely to have accidents than younger drivers. The importance of studying the financial aspects of retirement programs in the light of age distributions of employees is discussed.

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THE OLDER WORKER IN INDUSTRY: A SURVEY OF THE RETIREMENT PLANS OF THE LARGER NEW JERSEY MANUFACTURING ESTABLISHMENTS

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THIS report summarizes the results of a survey of the retirement plans of the larger manufacturing establishments in New Jersey. The purpose of the survey was to determine the extent of compulsory retirement, the ages at which employees are retired, the extent to which retirement pension benefits are paid, the amount of union participation in the administration of retirement programs, and the extent to which retired employees were rehired during the manpower shortages of 1947 to 1951.

MATERIAL AND METHODS

The survey was inaugurated in the fall of 1952 when questionnaires were mailed to 141 larger companies (arbitrarily defined as those establishments employing a total of 500 or more persons) engaged in manufacturing. The companies were drawn from a list based on the *Industrial Directory of New Jersey, 1946-1947* (1). One hundred and four replies were received; these were tabulated and analyzed during the spring and summer of 1953 and serve as the basis for this report.

It is important to emphasize that the findings of this survey are limited in several ways. First, the retirement plans of only 104 of the larger manufacturing firms in New Jersey were analyzed. According to the *Census of Manufactures, 1947* (2) there were 249 manufacturing establishments in the State employing 500 or more persons in 1947. Although no reliable figures are available concerning the number of such establishments in 1953, it is probably safe to assume that this survey covered approximately 40 per cent of these larger plants operating in New Jersey.

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Table 1 shows the distribution of the 104 returns, classified according to major industry groups as listed by the United States Bureau of the Budget in its *Standard Industrial Classification Manual* (3).

TABLE 1

INDUSTRY DISTRIBUTION OF QUESTIONNAIRE RETURNS

Industry Group	No. of Replies	Percentage of Total
Ordnance and accessories	1	1.0
Food and kindred products	10	9.6
Tobacco manufacturers	2	1.9
Textile mill products	9	8.6
Apparel	1	1.0
Furniture and fixtures	1	1.0
Paper and allied products	2	1.9
Printing, publishing, and allied industries	1	1.0
Chemicals and allied products	16	15.4
Products of petroleum and coal	3	2.9
Rubber products	4	3.8
Leather and leather products	1	1.0
Stone, clay, and glass products	3	2.9
Primary metal industries	7	6.7
Fabricated metal products	4	3.8
Machinery (except electrical)	10	9.6
Electrical machinery, equipment, and supplies	15	14.4
Transportation equipment	5	4.8
Professional, scientific, and controlling instruments	4	3.8
Miscellaneous manufacturing industries	5	4.8
Total	104	99.9

In addition, the retirement plans which are summarized apply only to hourly-rated employees. Although the salaried employees of

some companies are covered by the same retirement plans, a number of companies have different programs for them. Consequently, this study is not a survey of *all* employees who might be covered by retirement plans.

Finally, there are those limitations which are inherent in the mail questionnaire method used in making this survey. Despite every attempt to secure factual data from the respondents, subjective elements may have colored the replies to some of the questions. Furthermore, some of the questionnaires were completed by individuals who are removed from the local situation and, therefore, may not be aware of changes that may have occurred in the retirement practices at the plant level.

Results

Of the 104 companies whose replies were used in this survey, 17 reported that they have no retirement plan at all in effect for their hourly-rated employees (that is, they do not pay retirement pension benefits to any of their retired hourly-rated employees); 87 reported that they have a retirement program (that is, they pay retirement pension benefits generally under a formal plan, but in a few cases merely at the discretion of the company). The following information was obtained from those 87 companies having a retirement program of some kind in effect.

Extent of Compulsory Retirement.—For purposes of this survey, retirement is considered to be compulsory only at those companies which compel *all* hourly-rated employees, without exception, to retire when they reach a certain age. All other retirement programs are considered to be noncompulsory, and the established retirement age, if any, to be normal.

Seventy-three of the 87 companies having a retirement program reported that they have an established retirement age (either normal or compulsory or, in some cases, both) for hourly-rated employees. Thirty-three of these companies compel all hourly-rated employees, without exception, to retire when they reach a certain age; 40 companies do not compel all hourly-rated employees to retire when they reach a certain age.

Most of the retirement programs which do not have compulsory retirement provide that the employee, when he reaches normal retirement age and satisfies other requirements of the plan, has the option of retiring or continuing to work. In a limited number of cases, it is stated that the employee does not have this option, but that the company will grant a postponement in retirement if it requires the services of the employee beyond normal retirement date.

Retirement Ages.—Table 2 summarizes the retirement ages provided in the plans of companies with normal or compulsory retirement ages:

Table 2

Normal and Compulsory Retirement Ages for Hourly-Rated Employees of 71 Manufacturing Firms in New Jersey[1]

Retirement Age	Normal		Compulsory	
	Men	Women	Men	Women
55	0	2	0	1
60	0	3	0	4
65	41	36	22	17
68	1	1	8	8
70	1	1	2	2
72	0	0	1	1

[1] Two companies did not supply this information. Five companies reported both normal and compulsory retirement ages; 65 years is the normal retirement age for the 5 companies; 68 years is the compulsory retirement age for 4 of the companies, and 70 years is the compulsory retirement age for 1 company.

Fourteen of the 87 companies reported that they have no established retirement age. It seems that most of these companies use an informal, flexible method of determining when an employee should retire, in which several factors, including the wishes of the employee and his ability to perform the job adequately, are considered.

Pensions.—Of the 87 companies with a retirement program, 83 said that the retirement pension benefits are determined by a formula incorporated in the retirement plan, and 4 companies reported that they have in-

formal retirement programs which pay retirement pension benefits based on the needs of the older worker and, presumably, at the company's discretion. It is interesting to note that 72 of the 73 companies with an established retirement age pay retirement pension benefits which are determined by a formula, while 11 of the 14 companies with no established retirement age also use a formula for this purpose.

Sixty of the 87 companies reported that their hourly-rated employees do not contribute toward the cost of the basic pension benefits, while 26 said that their plans are contributory.[1] Several companies with noncontributory plans noted that their retirement plans also make provision for supplementary pension benefits to which their hourly-rated employees contribute.

The typical retirement plan provides that an employee may not collect his retirement income until he elects to retire. However, an interesting and unique feature of one of these plans is described as follows: "If the company, under extraordinary circumstances, requires your services after your normal retirement date, and you wish to remain in the active service of the company, application will be made to the Board of Directors. In the event such postponed retirement is approved, your contributions and the company's contribution under the plan will cease, and retirement income payments will begin on the same basis as if you had actually retired at your normal retirement date. However, your salary will be reduced by the amount of your retirement income."

Extent of Union Participation In Administration of Retirement Programs.—The hourly-rated employees of 82 of the 87 companies with a retirement program are represented by one or more labor organizations. Of these 82 companies, 18 had set up a joint labor-management committee to handle some of the problems associated with the retirement program. Six of these 18 companies reported that they have a compulsory retirement age, 8 a normal retirement age, and 4 have no established retirement age.

The functions of most of the committees are confined to the determination of facts relating to eligibility for retirement and the benefits to which an employee is entitled. A typical contract contains the following provision: "The Pension Committee shall have jurisdiction only to pass upon all questions concerning the rights of employees to retire, their eligibility for pensions and the amount of pensions to which they are entitled under the provisions of the pension Plan . . . ."

Two of the joint committees merely receive information concerning the operation of the retirement program. For example, one contract makes only the following reference to the function of the labor-management committee: ". . . Such Committee shall be furnished annually a report regarding the program of insurance and of the operation of the pension benefits in so far as it effects Employees. From time to time during the term of this Agreement, such committee shall be furnished with additional information as shall be reasonably required for the purpose of enabling it to be properly informed concerning the operation of the insurance program and of the pension benefits in so far as they affect the Employees."

Only one joint labor-management committee was found which handles a problem other than those associated with the determination of facts relating to eligibility to retire and the size of benefits; this committee also handles the important problem of determining the ability of the older worker to perform satisfactorily work assigned to him.

It seems that in most cases the company actually administers the retirement program while the joint labor-management committee serves as a grievance board to which are referred disputes involving the employee's rights under the plan. For example, a typical contract provides: "Subject to the provisions of the Plan, if any difference shall arise under the Plan between the Company and any Employee to whom this Agreement applies or the Union . . .

[1] One company did not answer on this point.

such difference shall be submitted in writing by such employee or the Union to the Joint Committee . . . ." In those cases where the joint committee administers the retirement program or acts as a grievance board, the decision of the committee is usually final and binding. If the committee is unable to resolve any dispute, the grievance is usually referred to some form of arbitration.

Where the committee acts merely to receive information, disputes involving the employee's rights under the terms of the pension agreement are adjusted under the regular grievance machinery set forth in the collective bargaining agreement.

Rehiring of Retired Employees.—Of the 87 companies with a retirement plan, 8 stated that they rehired formerly retired employees during the period 1947 to 1951. Two of these companies reported that they had worked out a procedure with the unions with which they bargained for handling the problems associated with the rehiring of formerly retired employees. It is interesting to note that neither of these 2 companies has a joint labor-management committee established to handle any of the problems associated with the retirement program.

In addition, one company had worked out the following agreement with the union with regard to the rehiring of formerly retired employees: "An employee who retires, or who is automatically retired under the terms of the Pension Agreement, shall cease to be an employee and shall have his seniority cancelled. If an employee . . . who has lost seniority in accordance with (this section) is rehired, such employee will have the status of a new employee and without seniority, and he shall not acquire or accumulate any seniority thereafter, except for the purpose of applying the provisions governing Holiday Pay and Vacation Pay."

Discussion

Although well over half of the companies surveyed do not have a compulsory retirement program (i.e., they do not require all hourly-rated employees, without exception, to retire when they reach a certain age), several of these companies indicated that they have only temporarily relaxed their automatic retirement provisions to permit their employees to remain on the job after they reached retirement age. Consequently, the number of cases in which management has the right, at its own discretion, to retire employees at a fixed age may be larger than indicated by the number of companies with a compulsory retirement policy, as defined in this report.[1]

Among the reasons which may explain the relaxation of automatic retirement provisions in a number of cases in recent years, the most important seems to be that pressures from both sides of the bargaining table have been favorable to the development of more flexible retirement policies. In the first place, recent years have been ones of relatively full employment. In times such as these, employers are more inclined to waive the right to retire employees. As one company put it, "Retirement at age 65 is at the sole discretion of the company. With the present manpower shortage, we are not retiring employees if they are physically and mentally capable."

In addition, unions generally have opposed the practice of retiring employees at a fixed age. When jobs are relatively plentiful, union opposition to the retirement of an employee at a fixed age, regardless of his ability to continue at work, tends to be at its height. One company wrote: "Unions have not accepted 65 as applicable to *all* employees. When a case is challenged and the employee so desires, we permit the employee to remain on the pay-roll" (respondents' emphasis).

Another important aspect of retirement programs is the extent to which unions participate in their administration. In only 18 companies is there formal provision for some form of union participation, other than through the normal grievance procedure. Moreover, in these 18 companies, only a very

[1] An interesting question which arises is whether or not a company retains the right to retire employees at a certain age after it has waived this right in a number of specific cases.

limited part of the whole retirement problem is considered by the joint labor-management committee. It may be that unions have generally chosen to act as critics through the grievance procedure and find this a satisfactory avenue of solving some of the problems associated with retirement of the older worker.

Finally, the survey tends to indicate that little has been done to utilize the services of retired personnel, for only 8 companies replied that they had rehired formerly retired employees. However, this does not necessarily indicate that companies have neglected this as a possible source of help in a tight labor market. It may mean that companies which do not have a compulsory retirement program keep the older worker on the job as long as possible. And in the case of at least some of those companies who retire all hourly-rated employees, without exception, at a given age, their retirement programs may be comparatively new so that sufficient time has not elapsed to permit the retirement of a significant number of workers.

Summary

A survey of the retirement plans of the larger New Jersey manufacturing establishments discloses that most of the companies surveyed have a flexible retirement policy; that automatic retirement provisions have been relaxed by management under certain conditions; that unions, generally, have not participated in the administration of retirement plans; and that little has been done by management to utilize the services of retired personnel during the manpower shortages of 1947 to 1951.

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Winants Hall, New Brunswick, New Jersey

AGING AND THE NATIONAL ECONOMY

E. T. GRETHER, Ph.D.

(From the Institute of Industrial Relations, University of California, Berkeley)

THE Institute of Industrial Relations is conducting a long-range research program dealing with aging, and reports concerning this research will be completed during 1954.[1] This present report may be considered as a preliminary view of some of the aspects of the economic portion of the research, together with some observations concerning issues in public policy. It is in no way a preview of the final reports and conclusions of the researches, and all data reported here are subject to correction.

Adequate treatment of aging and the national economy should cover the following areas, indicating in broad averages and percentages the magnitudes involved in so far as possible, and also the gaps in the data: 1) the proportion of the population in the aged group, 2) the needs of the aged and the adequacy of resources to meet these needs, 3) labor force status, 4) market demands and shifts in demands as related to aging, and 5) important general economic issues in private and public policy in providing for the aged.

There are important problems in defining "the aged." Until chronologic age can be related to physiologic, psychologic, and other factors, aging must be largely analyzed in simple chronologic terms, especially in so far as quantitative data are concerned, even though this approach oversimplifies the processes of aging. Therefore, in this report the aged for the most part are defined as those members of the population aged 65 and over. It should be realized, however, that many persons under 65 are in fact "older" than those above 65, and vice versa; thus persons should be considered as multiaged instead of merely as at one age level if full appraisal were possible. In other words, the traditional chronologic classification does not comprise a truly homogeneous group. Furthermore, from the standpoint of economic analysis, it is preferable to deal not in terms of individuals but rather in terms of aged economic units. We have found it useful to consider aged economic units as aged couples or as single individuals who do not have spouse present; likewise, we define an aged couple as one in which the man is age 65 or over, regardless of the age of the woman member of the couple.

In 1951 there were 9,800,000 aged economic units in the United States, of which 3,800,000 were couples; 1,800,000 were men, spouse absent; 4,200,000 were women, spouse absent. Although about 52 to 54 per cent of all persons 65 or over are women, single women outnumber single men by more than 2 to 1.

1. *The proportion of the population in the aged group.*—Table 1 indicates the number and percentage of total population of the United States aged 65 and over by 10-year intervals, 1900 to 1950, and two projections to the year 2,000 on the basis of the low birth rate of the 1930's and of the high birth rate of the 1940's.[2]

It is important to analyze the economic problem of the aged both in absolute and relative terms. The absolute figures indicate the total magnitude of the problem while the proportionate figures indicate its relative size.

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[1] The reports on the various aspects of the Institute's research program will be completed during 1954. Preliminary reports on some aspects of the large study on the *Economic Implications of an Aging Population* were presented before a meeting of the American Economic Association, Washington, D. C., December 28-30, 1953. These papers were published in the Spring, 1954, *Proceedings* issue of *The American Economic Review*. The authors and titles of the papers are: Robert Dorfman, "The Labor Force Status of Persons Aged 65 and Over"; Peter O. Steiner, "The Size, Nature and Adequacy of the Resources of the Aged"; Melvin Reder, "Age and Income." The authors are all associated with the Institute of Industrial Relations, University of California, Berkeley.

[2] These projections should not be taken as predictions. They represent the upper and lower ranges commonly used by demographers.

TABLE 1—UNITED STATES POPULATION

	Number (000) 65 Years and Over	Percentage of Total Population	
1900	3,080	4.0	
1910	3,950	4.3	
1920	4,933	4.7	
1930	6,634	5.4	
1940	9,019	6.8	
1950	12,332	8.2	
		Low Birth Rate Projection (30's)	High Birth Rate Projection (40's)
1960	13,900	8.4	8.3
1970	16,100	9.8	8.7
1980	18,500	11.2	9.0
1990	20,800	12.4	9.2
2000	20,300	12.1	8.0

The relative magnitudes are more significant for public policy than the absolute amounts. Thus, although the number of persons aged 65 and over quadrupled from 1900 to 1950, their percentage of total population merely doubled. According to the projection used here, the number of aged 65 and over will have increased by almost 7 times by the year 2,000 over the year 1900, but the relative increases will have been only 2 or 3 times, depending upon the assumption as to birth rates. Presumably our capacity to meet the economic problems of the aged is related much more directly to the relative figures than to the absolute ones.

2. *The needs of the aged and the adequacy of resources to meet these needs.*—Our final reports will consider the size of the gap between the receipts of the aged in dollar values and the amounts in dollars, under various assumptions, required to meet their needs. Even in terms of the recent period of high prosperity and near-full employment we know that there is a sizeable aging receipts gap on the basis of estimates of reasonable minimum needs.

In our society a reasonable standard of living can never be an absolute or determined by administrative fiat. To begin with, it will be influenced enormously by the actual consumption experience (plane of living) of the persons involved and of others with whom they make comparisons. J. B. Peixotto, the pioneer in the field of budget studies at the University of California, once remarked that poverty is largely income contrast rather than an absolute state. Thus, agreement as to the content of reasonable minimum needs inevitably involves sociologic, psychologic, and political factors, as well as economic. There are, of course, reasonable minimum physiologic and health requirements or adjustments and creative adaptations in housing as related to aging, but the end product of research cannot and should not be a simple dollar figure applicable to all persons, times, and places. In pointing this out I do not wish in any respect to cast doubts upon the value of the contributions of the specialists who are at work in the field, or at the estimates of the costs of maintenance. More and better evidence on all aspects of requirements, especially those uniquely related to the processes of aging, are needed.

Our knowledge of the receipts of the aged available to provide for their needs is more adequate than is our knowledge of the needs themselves. Our special studies on a sampling basis indicate that in 1951 about 20 per cent of the aged economic units either had no source of money receipts or such receipts were less than $200 a year. The remaining 80 per cent had money receipts from at least one source divided approximately as follows as to primary sources:

Earnings	30 per cent
Assets and savings	20 per cent
Pensions (including OASI)	25 per cent
Public and private relief and contributions	25 per cent

That is, about one-half of those with measurable receipts received them from private earnings and assets, about one-fourth from pensions, including OASI, and about another one-fourth from public and private relief programs and contributions.

Unfortunately we cannot indicate exactly the magnitude of the receipts available to the

aged from these sources. Information concerning potential receipts available from some forms of assets, including savings and property, is fragmentary and inadequate. We recommend strongly that agencies such as the Federal Reserve Board, which study savings and assets, include a larger proportion of the aged in their samples.

Likewise, we cannot now provide adequate estimates of the sharing of receipts among members of family units. Our survey indicates that approximately one-third of all aged economic units live with their children. Obviously under these circumstances the total income of the family unit is shared to some extent. We hope eventually to have something to present in quantitative terms concerning the contribution of such sharing toward bridging the aged receipts gap. It should be noted that this process is not unilateral, for the aged may also contribute to the income of the other members of the family group. Our sample data indicate, however, that the money contributions of the aged to the group as a whole are relatively small in contrast to the contributions to their support. This conclusion, of course, does not allow for services performed by the aged within the family unit, such as household work, baby sitting, and gardening. Much of this type of activity, important though it may be, must remain outside the bounds of national income estimating.

It is evident, however, that there has been a sizeable gap between the dollar resources required to meet the needs and the receipts available even under recent conditions of high prosperity. Our sample data for the total money income of aged economic units reporting income for the year 1951 indicates a medium income of only $682, with 41 per cent reporting annual incomes under $500, and 24 per cent within the range of $500 to $999. Only 25 per cent had money incomes of $1,500 or larger and but 6 per cent enjoyed incomes above $4,000.

3. *Labor force status:*—It is commonly assumed that there is an enormous reservoir of unutilized manpower among the aged which represents a wasted national resource. Similarly, it is sometimes held that if the aged were employed they could themselves carry much of the burden of their support. There is the general belief also that the creative energies of the aged are stifled, thwarted, or deflected by compulsory retirement from employment.

Our national sample for April, 1952, indicates that about 28 per cent of persons 65 and over were still in the labor force. Approximately 20 per cent had never worked, (or were women without work experience since age 50), 42 per cent were not well enough to work, 4 per cent were able to work but not interested, and 6 per cent were able to work and willing to take occasional employment. Another analysis disclosed that during 1951 about two-thirds had not been employed and only 20 per cent had worked from 26 to 52 weeks during the year. The remainder of those employed had worked only part-time or at most less than 26 weeks. These two sample results suggest that about one-fourth of persons 65 and over may be considered in the labor force in a full sense. This percentage contrasts with about 65 per cent for all persons aged 25 through 64 and 58 per cent for the total population aged 14 and over in the civilian labor force. In 1950 almost the entire able-bodied male population aged 25 through 54 was in the civilian labor force in contrast with 38 per cent for women. At age 65 and above, 45 per cent of the men were still in the labor force and 10.5 per cent of women. A strange and perhaps paradoxic aspect of labor status is that about twice as many men who have wives are still in the labor force than are men who are living alone. This phenomenon well illustrates the necessity for interdisciplinary analysis for it clearly cannot be explained merely in economic terms.[1]

Our sample results suggest that the majority of the aged cannot be expected to be active, regular members of the nation's work

[1] Discussion of the occupational distribution of those gainfully employed is omitted. The published reports will include evidence in terms of 3 classifications: present occupation, longest occupation, and last occupation. The last 2 classifications represent innovations in data collection.

force. The existing participation of about one-fourth may represent approximately the optimum, but we are not now prepared to reach a final conclusion. Clearly, however, there is not presently a large unutilized reservoir of man power. This tentative conclusion suggests the contrary issue in public and private policy as to the ability of this proportion of the aged to remain in the work force of the nation. Personally, I believe that those who are physically and mentally capable of full participation should be allowed to do so regardless of pension rights.

4. *Market demands and shifts in demands as related to aging:*—As indicated previously estimates of the needs of the aged must begin with their recent and current consumption behavior. For this purpose and others, studies are needed of the degree to which effective demand in our markets is modified by aging. Effective demand reflects both the economic ability of the aged to enter our markets as well as their specific wants and desires. Detailed knowledge of effective demand is the foundation stone of all endeavors to estimate needs and for the determination of public policy in a free society. If public policy assumes that the aged will continue to have free choices as consumers, then knowledge of the existing patterns of market demands is mandatory. This is not to say that consumption behavior may not be influenced and perhaps even considerably directed by expert counsel and assistance. But we must not fall into the trap of setting up programs of care for the competent aged which run counter to the principles of democratic choice. Thus, in addition to the budget studies of needs we also must investigate more thoroughly the existing patterns of consumer choice. Presently, our knowledge of the behavior of the aged as consumers is illuminated largely by hypotheses for testing and more or less informed speculation.

5. *Important issues in public and private policy.*—From the standpoint of the functioning of the economy as a whole and the relevant issues of private and public policy, we should have an adequate estimate of the magnitude of the gap between the money receipts available from private sources and the total reasonable estimated dollar needs of the aged. Knowledge of this so-called aging receipts gap and of the effect of aging upon the aggregate consumption functions would provide a basis for a reasonable discussion of economic policy at any given time. Eventually our reports will present data on the relative magnitudes involved under various sets of assumptions. We will also be able to throw considerable light upon the problem of the degree to which the gap represents submarginal living by American standards or is bridged by intrafamily sharing of income and facilities.

It should be noted that the conclusions reached concerning policy could not be universally applicable for all economies or for all time periods in a given economy. The ability of an economy to bridge the aging receipts gap and the impact of such outlays upon the relative stability of the economy are influenced by both the quality of resources available and the degree of utilization of resources in the broad swings of economic fluctuations. Important also are the standards of living prevalent in the economy. In the United States, reasonable minimum requirements must be higher than elsewhere in the world in order to fulfill not only physiologic needs, but psychologic, political, and other requirements.

Although the magnitude of the responsibility even in good times and especially in poor times, should not be underemphasized it may be surmised that once we have reasonable quantitative estimates, we shall discover the essential outlays entirely manageable in terms of the functioning of the economy as a whole, especially if public and private pension programs are properly planned and integrated. Although the outlays undoubtedly would be sizeable, it may turn out that they would represent a relatively small proportion of the national income. Unless our productive capacities have been greatly depreciated by war or in other ways, it should be entirely possible to fit a program of reasonable pro-

vision for the aged into our national economic scheme of things. The issues are largely political and sociologic, rather than economic.

From a political standpoint the issues primarily concern our ability to keep such programs from becoming the footballs of politics, and to integrate local, state, and federal public programs and private programs. Particularly important is the political ability and willingness to integrate such programs appropriately into the total functioning of the economy throughout the broad fluctuations of employment. We have not as yet fully demonstrated in the field of social security that we have the political capacity to make the wiser moves in terms of both national economic policy and the needs of recipients. For instance, our unemployment insurance program is not on a sound basis in terms of reasonable adjustments to broad economic fluctuations in employment.

It seems possible to generalize safely with respect to other issues also, so far as economic factors are concerned. In our society there should be no discouragement to individual and other private means of providing for the needs of old age. All persons should, if at all possible, contribute to systematic programs for providing incomes for their old age. A soundly conceived national program in an over-all sense must integrate both public and private means. We are now well on the way toward working out such a broadly integrated program, but much remains to be done in integrating private pension schemes and public programs. The combination of private and public systems for providing for old age should be planned and integrated so that the total income at the appropriate age of retirement will provide for reasonable minimum needs, both of recipients and their dependents.

It is probable that eventually the total gap between the minimum reasonable needs of the aged and their regular receipts and resources will be much smaller than at present. Obviously, there are numerous means of accomplishing this objective. The expansion of coverage and benefits under the federal O.A.S.I. beginning in 1951, and again in 1952, was a step in the right direction, as is also the further expansion now proposed by the President of the United States. Other means will not be discussed in this report except to reiterate the importance of maintaining private incentives for providing for old age, and to add the equivalent importance, therefore, of allowing those individuals who have done so to enjoy a differential above the minimum when their accumulations so allow.

Summary

A report is presented on aspects of the economic portion of research being conducted at the Institute of Industrial Relations of the University of California, together with some observations concerning issues in public policy. The following aspects of aging and the national economy are touched upon: the proportion of the population in the aged group, the needs of the aged and the adequacy of resources to meet these needs, labor force status, market demands and shifts in demands as related to aging, and important general economic issues in private and public policy in providing for the aged.

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Program of the Division of Biological Sciences Seventh Annual Scientific Meeting of the Gerontological Society, Inc.

UNIVERSITY OF FLORIDA, GAINESVILLE, FLORIDA
TUESDAY, DECEMBER 28, 1954

A. I. LANSING, *Program Chairman*, Division of Biological Sciences

Morning Session, 9:30 a. m.—12:00 noon

Chairman: A. I. LANSING, Emory University School of Medicine, Emory University, Georgia

PARFENTJEV, I. A.—Changes in Serum Protein During Aging in Humans and Animals.

ANDREW, W.—An Age Difference in the Epidermis of Wistar Institute Rats Based on Regional Differences in Skin.

KIRK, J. E., and LAURSEN, T. J. S.—Changes With Age in Diffusion Coefficients of Solutes for Human Aortic Tissue.

LAURSEN, T. J. S., and KIRK, J. E.—Diffusion Coefficients of Carbon Dioxide and Glucose for a Simple Connective Tissue Membrane in Individuals of Various Ages.

HAMILTON, J. B.—Relationships Between the Quantity of Bodily Fat in Man and Titers of Urinary Steroids, with a Consideration of the Possibility that Adverse Influences of Obesity Are Mediated in Part by Steroids.

PAPEZ, J. W.—Changes in Nerve Cells and Hypophysis in Old Psychotic Patients, A Review of 90 Cases.

Afternoon Session, 2:30—4:30 p. m.

Chairman: W. ANDREW, Bowman Gray School of Medicine, Winston-Salem, North Carolina

BERG, B. N.—Blood Pressure in Aging Rats.

LANDOWNE, M., SILVER, H. M., and SILVERSTONE, F.—Changes in Skin Temerature with Age.

LANSING, A. I.—Some Systemic Effects of Elastase.

KIRK, J. E., and LAURSEN, T. J. S.—The Presence of Succinic Dehydrogenase and of Krebs' Cycle Enzymes in Human Aortic Tissue.

HESS, A., and LANSING, A. I.—The Fine Structure of Young and Old Spinal Ganglia.

ROGERS, J. B., and TAYLOR, R. C.—Age Changes in the Female Reproductive System of the Guinea Pig.

Read By Title:

LESCANEC, G. L., and SODERWALL, A. L.—The Reaction of the Senescent Testis to an Androgen-Estrogen Combination in the Male Hamster, *Mesocricetus auratus*, Waterhouse.

Evening Session, 8:00—10:00 p. m.

SYMPOSIUM

Calcification

(Panel to be announced later)

Abstracts of Scientific Papers

An Age Difference in the Epidermis of Wistar Institute Rats Based on Regional Differences in Skin.

W. ANDREW, *Department of Anatomy, Bowman Gray School of Medicine, Winston-Salem, North Carolina.*

A study of the skin of Wistar Institute rats of 3 age groups, young (21 days), middle-aged (300 days), and senile (900 days and over) has been made, with particular reference to the number and appearance of the special cell types, the lymphocytes, intermediate cells, and clear cells. Criteria for the assigning of cells to these categories, on the basis of size, nuclear structure, shape of the cell body, and appearance of the cytoplasm, with some attention to cytoplasmic organelles, are considered. Using these criteria, it is shown that the differences in numbers of these cell types at different ages are not significant in the epidermis from the interscapular region of the back but that the differences in the epidermis of the abdominal skin are highly significant. Possible reasons for the difference in numbers of migrating cells in these two regions and for the age change in one region and not in the other are discussed.

These studies were aided by a contract between the Office of Naval Research, Department of the Navy, and the Bowman Gray School of Medicine, NR 102 024.

Blood Pressure In Aging Rats.

B. N. BERG, *College of Physicians and Surgeons, Columbia University, New York, New York.*

The blood pressure in rats increases with aging. In males, values rise from 119 mm. at 584 days to 133 mm. at 677 days and 138 mm. at 853 days. In females there is a gradual increase from 114 mm. at 338 days to 130 mm. at 869 days and 132 mm. at 1,037 days. The range of blood pressure is wide at all ages but is greatest in older rats. The upper limit for animals less than 636 days of age is 144 mm., while in older rats readings from 145 mm. to 191 mm. are recorded. About 30 per cent of rats more than 800 days of age have blood pressures over 144 mm. and in approximately 20 per cent values are 150 mm. or higher. In general blood pressures are higher in males than in females. These studies were made on 118 male rats and 73 females.

All of the rats with elevated blood pressures had renal disease, but there were also a considerable number of animals with the same degree of renal pathology without hypertension. Pheochromocytomas of the adrenal medulla were found in several hypertensive animals but were also present in normotensive rats.

Blood pressure was determined indirectly by means of a photoelectric cell which measured the volume change that occurred in the foot after the application of a sphygmometer cuff to the ankle.

Relationships Between the Quantity of Bodily Fat in Man and Titers of Urinary Steroids, With a Consideration of the Possibility That Adverse Influences of Obesity Are Mediated in Part by Steroids.

J. B. HAMILTON, *Department of Anatomy, College of Medicine, State University of New York, Brooklyn, New York.*

In normal men 3 independent measures of bodily fat were found to correlate with titers of urinary

ketosteroids in both colorimetric (+.675 to +.861, P=.008–.001) and androgenic assays (+.770 to +.796, P=.004 – .001). In middle-aged men lower, but still statistically significant, correlations were observed with colorimetric but not androgenic values. In old age the relationship to ketosteroids was no longer significant. Both adrenocortical and testicular secretions, as judged by their urinary metabolites, participate in this relationship to bodily fat.

Urinary 17-hydroxycorticosteroids, which are metabolites that provide a good gauge of the chief adrenocortical secretion in man, compound F, were measured in 21 castrate men to avoid complications introduced by testicular secretions. Titers tended to be higher in obese than in non-obese eunuchs.

The effects known to be produced by steroids which are present in augmented quantities in fat subjects, when compared with diseases which are especially common in the obese (such as diabetes), suggest that alterations in the turn-over of steroids may play an etiologic role in certain of these pathologic states.

The Fine Structure of Young and Old Spinal Ganglia.

A. HESS and A. I. LANSING, *Department of Anatomy, Washington University School of Medicine, St. Louis, Missouri, and Department of Anatomy, Emory University School of Medicine, Emory University, Georgia.*

Ultrathin sections were made of the spinal ganglia of 3 day old, adult, and 6 year old guinea pigs fixed in osmic acid and embedded in plastic. Two nerve cell types are observed, mainly based on the distribution of the Nissl substance. The cell membrane of the nerve cell can be smooth or can present thin villiform projections containing nerve cytoplasm. No evidence of neurofibrils or a Golgi apparatus is seen. Nissl substance is composed of very fine tubular elements, which are highly oriented when the chromophil substance occurs in clumps. The mitochondria are small, thin, and elongated and present numerous, closely-spaced folds. The cell membrane of the satellite cell invaginates and forms pockets to receive the villi of the nerve cell. The cytoplasm of the satellite cell is relatively devoid of formed elements. The satellite cell nucleus can cause an indentation in the nerve cell cytoplasm. Satellite cell cytoplasm always encapsulates the neuron. Satellite cells frequently form a syncytium with each other.

Degenerative mitochondria can be found in young nerve cells and normal mitochondria are seen in senile cells. It is difficult to use the condition of the mitochondria as an index of aging. All senile ganglion nerve cells present pigment. The appearance and distribution of the pigment bodies are described. A suggested series of stages of pigment formation is presented.

Changes With Age in Diffusion Coefficients of Solutes for Human Aortic Tissue.

J. E. KIRK and T. J. S. LAURSEN, *Division of Gerontology, Washington University School of Medicine, St. Louis, Missouri.*

Determinations have been performed of the diffusion coefficients* of various gases and non-gaseous solutes on 51 preparations of the intima (with attached subintimal tissue) and 50 preparations of the media of the human aorta. The age of the individuals from whom the samples were derived ranged between 10 and 80 years. The measurements were carried out under sterile conditions by the procedure of S. G. Johnsen and J. E. Kirk.

The following mean diffusion coefficients for the intima samples were found: nitrogen 0.00047, oxygen 0.00050, carbon dioxide 0.00040, lactate 0.00012, iodide 0.00032, and glucose 0.00010. For the media preparations the average diffusion coefficients were: nitrogen 0.00055, oxygen 0.00058, carbon dioxide 0.00038, lactate 0.000084, iodide 0.00026, and glucose 0.000076.

A calculation of the product values: diffusion coefficient x 5MW showed that the product values for nitrogen, oxygen, and carbon dioxide (MW 28 to 44) were over two times greater than the product values for lactate (MW 90) and glucose (MW 180). These findings might indicate the presence in the aortic membrane of a set of smaller pores (permitting the passage of compounds of MW 28 to 44) and a set of larger pores (permitting the passage also of compounds of MW up to 180).

A tendency was observed for the diffusion coefficient values to increase with the age of the individuals. The coefficients of correlation between age and the diffusion coefficients were as follows for the intima samples: nitrogen + 0.28 (t=2.04), oxygen + 0.18 (t=1.27), carbon dioxide + 0.23 (t=1.66), lactate + 0.46 (t=3.60), iodide + 0.38 (t=2.89), and glucose + 0.58 (t=4.99). For the media preparations a similar tendency to an increase in permeability with age was noted, the correlation coefficients being: nitrogen + 0.35 (t=2.60), oxygen + 0.29 (t=2.08), carbon dioxide + 0.36 (t=2.67), lactate + 0.41 (t=3.12), iodide + 0.39 (t=2.93), and glucose + 0.44 (t=3.35).

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* Units of the substance diffusing through 1 cm.^{2} of the membrane in 1 minute at a concentration gradient of 1 unit per ml. per cm. (A. V. Hill).

The investigation was supported by a grant (PHS-891) from the National Heart Institute of the National Institutes of Health, Public Health Service.

The Presence of Succinic Dehydrogenase and of Kreb's Cycle Enzymes in Human Aortic Tissue.

J. E. KIRK and T. J. S. LAURSEN, *Division of Gerontology, Washington University School of Medicine, St. Louis, Missouri.*

Investigations were carried out on the dehydrogenase activity of human aortic tissue, using a quantitative tetrazolium technique. Experiments were performed under sterile conditions on 25 aortic samples. Annular segments of the thoracic aorta, consisting of the intima and media, were placed at 37 C. in a triphenyltetrazolium chloride-phosphate buffer solution, to which had been added glucose, lactate, pyruvate, acetate, or one of the intermediate compounds of the Krebs' cycle in 0.15 molar concentration. The formed formazan was extracted with acetone and determined spectrophotometrically.

A notable succinic dehydrogenase activity of the aortic tissue was found, an average of 0.182 mg. of formazan being formed by 1000 mg. fresh tissue per hour. The formazan formation without addition of substrate valued 13 per cent of the succinic dehydrogenase activity. For the remaining substrates the following rates of tetrazolium reduction were encountered, expressed in percentage of the formazan formation in succinate medium: glucose 15%, lactate 17%, pyruvate 10%, acetate 28%, cis-aconitate 49%, citrate 31%, alpha keto glutarate 36%, malate 23%, and oxalacetate 27%. Addition of malonate in 0.03 molar concentration produced an 80 per cent inhibition of the succinic dehydrogenase activity.

The investigation was supported by a grant (PHD-891) from the National Heart Institute of the National Institutes of Health, Public Health Service.

Changes in Skin Temperature With Age

M. LANDOWNE, H. M. SILVER, and F. SILVERSTONE, *Section on Gerontology, National Heart Institute, National Institutes of Health, P.H.S., D.H.E.&W., Bethesda, Maryland and the Baltimore City Hospitals, Baltimore, Maryland.*

Seventy-eight subjects aged 26 to 92 years (mean age 58) clinically without disorders of the peripheral circulation or general metabolism, were each studied at least twice under standardized environmental conditions; moderate, constant temperature, and minimal air movement. After lying unclothed for 90 minutes in a room at 22.7 C, the average temperature of the third finger tip was 23.20 ± 0.60 C. and showed no significant change with age. These values are lower than those usually cited for similar environmental conditions. The right fingers averaged 0.31 ± 0.66 C. warmer than the left, a small but statistically significant difference. Such asymmetry has been noted by other workers. The difference tended to decrease by about 0.1 C. per decade.

For the third toe, the average temperature after "equilibration" was 22.97 ± 0.87 C. and showed a significant agewise *increase* of 0.25 C. per decade. Asymmetry was also present, the right toe averaging 0.33 ± 0.50 C. more than the left, without discernible age change.

Under these experimental conditions, the finger-toe difference although small, diminishes significantly and may become reversed in older subjects. Since the surface temperature of the extremities is related to the activity of the skin areas in heat dissipation, there may be a greater relative heat loss in the toes of older subjects at rest in a cool environment. The known decline in basal heat production with age supports this interpretation of our data as a relative failure of the toes to conserve heat. Alternative explanations of these changes are possible.

Some Systemic Effects of Elastase.

A. I. LANSING, *Department of Anatomy, Emory University School of Medicine, Emory University, Georgia.*

Elastase is a relatively specific enzyme which effects a solubilization of elastic tissue in vitro. We have recently found that in a teleost fish, in which the islet and acinar components of the pancreas are anatomically separate, the elastase is confined entirely to the islet tissue, suggesting a possible systemic action of this material. Oral administration of elastase to rabbits injected with C-14 labelled glycine or acetate resulted in significant changes in the uptake and turnover of the isotope in elastin extracted from the aorta. Further, elastase orally administered to rabbits on a high cholesterol diet almost completely inhibited the formation of fatty livers and significantly retarded the development of atheromatosis. The possible significance of these observations will be discussed.

Diffusion Coefficients of Carbon Dioxide and Glucose for a Simple Connective Tissue Membrane in Individuals of Various Ages.

T. J. S. LAURSEN and J. E. KIRK, *Division of Gerontology, Washington University School of Medicine, St. Louis, Missouri.*

Determinations have been performed of the diffusion coefficients of carbon dioxide and glucose on 35 samples of the tentorium cerebelli, derived from individuals ranging in age between 1 and 78 years. The measurements were carried out under sterile conditions by the procedure of S. G. Johnsen and J. E. Kirk.

The mean diffusion coefficient observed for carbon dioxide was 0.000436 for young individuals (1 to 39 years), 0.000442 for middle-aged persons (40 to 59

years), and 0.000449 for old subjects (60 to 78 years). For glucose the corresponding average coefficients were 0.000129, 0.000114, and 0.000128.

No significant change in the permeability of the tentorium cerebelli with age could thus be revealed by this technique.

The investigation was supported by a grant (PHS-891) from the, National Heart Institute of the National Institutes of Health Public Health Service.

The Reaction of the Senescent Testis to an Androgen-Estrogen Combination in the Male Hamster, Mesocricetus auratus, Waterhouse.

G. L. LESCANEC and A. L. SODERWALL, *Department of Biology, University of Oregon, Eugene, Oregon.*

While many investigators have been interested in the various effects produced on tissues by either an androgen or an estrogen, little work has been done on the effect produced by a combination of the two hormones, particularly with regard to senescent tissues. This work involved the use of 12 senescent hamsters, 8 of which were given ¼ cc. injections every other day for a total of 6 injections, containing testosterone propionate (50) and estradiol benzoate (2½) in a twenty to one ratio. It has been found that a specific ratio of androgen to estrogen normally exists for each individual and variations from this ratio are not marked; thus a specific ratio was found to be most effective.

The effects of administration of combined testosterone propionate and estradiol benzoate on testicular tissue were: 1) establishment of near tubule and lumen size with an increase in spermatogenic activity; 2) while an increase occurs in the basement membrane with aging, no further increase was noted as a result of hormone administration and 3) decrease in interstitial tissue.

While large amounts of androgen or an estrogen are capable of producing a marked suppression of testicular function, this effect can be prevented if smaller quantities of both are given simultaneously. The action of the two hormones on the testis is probably mediated through their suppression of the pituitary gonadotrophin.

Changes in Nerve Cells and Hypophysis in Old Psychotic Patients. A Review of 90 Cases.

J. W. PAPEZ, *Laboratory for Biological Research, Columbus State Hospital, 1960 West Broad Street, Columbus, Ohio.*

Records of microscopic findings in brain and hypophysis cerebri from 90 patients over 65 years of age were reviewed in order to show specific agencies related to advanced degeneration of nervous tissue. Age of 65 patients was 65 to 80 years; 25 were 80 to 90. The usual diagnosis was senile psychosis. A few other types were included. Deterioration was usually present. Organic and chronic brain syndromes were indicated. Pulmonary, cardiac, vascular, gastro-intestinal, infections, or metabolic disorders, etc., were frequent.

At autopsy, senile encephalopathy, with or without arteriosclerosis and vascular lesions, was often seen. Cortical atrophy, dilated ventricles and changes in white matter were common. Usual histologic methods showed fatty degeneration in nerve cells, demyelination of nerve fibers, gliosis of supporting tissue, and various necrotic changes. No specific agency associated with degeneration in nervous tissue was revealed by old methods, and new methods were devised.

Our researches were directed to solution of this problem. We have used oil immersion, phase microscopes to show presence of living organisms in degenerating nerve cells. A common factor was a massive infestation of cytoplasm of nerve cells, concentrated in thalamus, cerebral cortex, and hypophysis cerebri. The latter gave a clear picture of life-cycle, from spore-cases to elementary bodies, ring-forms, and reproductive protoplasts which formed inclusion bodies in cells. A minor cycle occurred in red blood corpuscles, from elementary bodies to statoblasts producing elementary bodies of small size in mucoid sacs. Heat treatment, 45 to 55 C., induced rapid increase of elementary bodies to ring-forms. Organisms resembled polyhedral insect viruses. Damage to nerve cells was general. There was partial or total destruction of pyramidal and granule cells, and cells of the thalamus. Nuclear metabolism was affected. Main features will be shown.

Changes in Serum Protein During Aging in Humans and Animals.

I. A. PARFENTJEV, *Department of Microbiology, Yale University School of Medicine, New Haven, Connecticut.*

In chickens and dogs serum protein pattern changes during the life span from the early days on. Mainly, it is manifested in the increase of globulin, while the concentration of albumin remains steady. In adult chickens, the concentration of globulin is so augmented that the albumin/globulin ratio becomes reversed (Parfentjev and Duran-Reynals, 1951; Parfentjev and Whitney, 1952). Contrary to this, in human beings serum protein pattern remains remarkably unchanged

during the life span. We investigated serum fractions in healthy people from 20 to 90 years of age, both male and female, and we found (in the great majority of individuals of each age group) the same "youthful" pattern of serum protein. The abnormal serum protein pattern was observed in patients with disease, and only exceptionally in the absence of evident illness.

These findings suggest:

1) Apparently in animals during their lifetime the alteration of serum fractions toward the reverse ratio of albumin and globulin is due, not to the aging, but rather to unsanitary conditions and contact with germs, since we know that hyperimmunization leads to considerable increase of the globulin fraction;

2) The presence of normal serum protein pattern in healthy people during life span stresses the importance of serum fractionation for diagnostic purposes;

3) Although much evidence has been presented that serum protein pattern might be a very important index for health and disease, the fractionation of serum protein as a diagnostic procedure has not been adequately exploited.

The main obstacle was due to the fact that present methods for protein analysis—electrophoretic and salting out methods—are not applicable for diagnostic laboratories and mass analyses.

On the other hand, the turbidimetric analysis of serum protein offers the possibility of introducing this important tool for diagnostic purposes. Complete fractionation of serum and plasma protein by turbidity requires only a few minutes and only 1 to 2 cc. of blood, is not dependent on interfering substances, and yields reliable results (Parfentjev and Johnson, 1952; Parfentjev, Johnson, and Cliffton, 1953).

This investigation was supported by a research grant (USPHS C 1201 (C3) from The National Cancer Institute, of the National Institutes of Health, Public Health Service.

Age Changes in the Female Reproductive System of the Guinea Pig.

J. B. ROGERS, *Department of Anatomy, and* R. C. TAYLOR, *Department of Pathology, University of Louisville, School of Medicine, Louisville, Kentucky.*

Changes in the female reproductive system due to aging have been observed in the study of tissues of female guinea pigs dead from various causes. Most of the deaths were associated with toxemia of pregnancy. The toxemia of pregnancy, a disease of certain families of guinea pigs, was reported by Rogers, Van Loon, and Beattie in 1951.

A colony of guinea pigs containing animals of various age groups susceptible and non-susceptible to toxemia of pregnancy has been maintained for more then ten years. The age groups, based on known ages of the animals are classified as follows: 1 to 365 days, young; 366 to 730 days, mature; 731 to 1095 days, old; 1096 days or more, senile.

The marked diminution of reproductivity during the fourth year of life has been reported by Rogers in 1951. Tumors of the uterus and ovarian cysts have been found in senile animals. The tumors of the uterus have been leiomyomas, myxosarcomas, and leiomyosarcomas. One case of apparent endometriosis has been found. The ovarian cysts have largely been retention cysts, particularly of the rete ovarii and some have been serous cystomas. Progressively with age and repeated pregnancies the uteri have enlarged in size. With extreme age, however, wrinkling and atrophy have occurred. The walls of the uterine blood vessels have become progressively thicker. The greatest changes so far observed between toxemia susceptible and toxemia non-susceptible animals have been in pregnant uteri and placentas. In toxemia susceptible animals the decidua showed greater necrosis and calcification, and the placentas were larger, yellower, more hemorrhagic, and more necrotic.

Aided by a grant from the U. S. Public Health Service and by a grant to the University of Louisville from the Kentucky State Medical Research Commission.

BOOK REVIEWS

ADD LIFE TO YOUR YEARS, by Ernst P. Boas, McBride Company, New York, 1954, 278 pages, $3.75.

The increasing number of books appearing relative to the problems of the later years of life is in response to public interest. The spectacular shift in the age groups of our national population has created new problems of individual and social significance which must be solved if the older citizens are to enjoy their lengthening life span.

This recent volume, *Add Life to Your Years*, by Ernst Boas, M.D., represents the thinking of a recognized authority. His researches on the problems of the circulatory system and his broader interest in the social aspects of older people have provided a rich and varied experience which has served as the source for the current work.

The book contains 17 newsy chapters on the highlights of body changes, maladies, and deteriorations which are the most common experiences of growing older. The discussion of diseases of the heart and arteries and of the blood pressure and its abnormalities should prove comforting to many individuals who fear the disturbances that afflict the vascular system of the body. The book concludes with a discussion of euthanasia and finally a consideration of social attitudes toward aging. This latter chapter might well have been augmented considerably since the solution of the social problems of this age group represents ultimately the major challenge which longer life has precipitated for society.

While there is nothing new in this small volume, it is well worth an evening's reading, which will prove profitable as well as entertaining for the many who are looking forward with increasing confidence to a satisfactory existence in the higher years of life.

E. L. BORTZ
Philadelphia, Pennsylvania

HOW TO BE A WOMAN, by Lawrence K. Frank and Mary Frank, The Bobbs-Merrill Company, Inc., New York, 1954, 144 pages, $2.75.

This little book might be described as a capsule of sound information and advice for women, which, however, should probably not be taken all in one dose. In effective but never affected language, the authors express their conviction of the dignity and worth of human beings and "especially in the unlimited human potential of women" (page 5). It is intended by the authors to serve as a manual to be referred to from time to time with the crossing of thresholds of different life periods such as girlhood, young womanhood, the busy years from 20 to 40, the middle years from 40 to 55, and the years after 55. Although containing much useful information, it is frankly an inspirational book which frequently goes beyond established facts into the realm of gentle exhortations. By stressing the continuity of the female life pattern from one age period to the next, the authors hope to clarify some of the responsibilities and privileges involved in playing the feminine role.

The book is divided into 6 major sections, 5 dealing with major periods of life and the other a recapitulation of childhood from the vantage point of a mother. Each section is addressed in the present tense to the age group being described. This makes for smooth continuity of language and style but seems to make the error of assuming that readers of all ages are equally capable of comprehending what is being addressed to them. The authors apparently recognize this difficulty and suggest that both a prospective and retrospective look will help a woman to attain the goals of the different periods.

An interesting feature of the book is the emphasis on the changing roles which must be played by women at different periods of life and on the diversity of roles which must be managed by a woman at any given period. Implicit in this is a plea for a more adequate handling of the simultaneous roles and an avoidance of rigid devotion to one as opposed to another (e.g., being a mother to the exclusion of being a wife).

The book is accompanied by some pleasant art work and several informative diagrams. It does not say anything completely new, but it presents succinctly and effectually what might be regarded as a plausible interpretation and assimilation of the available material upon which such generalizations can be based. The book will probably have greatest utility in high school and college classes dealing with approaches to life adjustment and to adult study groups which need some literary guide as an aid in placing their constantly emerging problems in proper perspective.

BETTYE McD. CALDWELL
Department of Psychology
Northwestern University

AGING AND RETIREMENT, The American Journal of Sociology, *59*: 301-409, 1954, Ernest W. Burgess, special editor, $1.25.

The issue is edited by Ernest W. Burgess, Professor Emeritus of Sociology of Chicago University, who, as consultant to the University's Industrial Relations Center, has organized a research program on retirement.

The articles are contributed by Burgess and eleven others, who, with few exceptions are on the staffs of the University of Chicago, the University of Florida, and the Mooseheart Research Laboratory.

The lead article by Clark Tibbitts discusses retirement problems in American society. He says that retirement is a relatively new phenomenon because of the rapidly increasing proportion of older persons and scientific and technologic achievements, leading to greater productivity, shortening the work week, and producing greater unemployment. He identifies and discusses the principal problems faced by the individual, such as maintenance of income, discovery of new occupations or social roles, finding opportunities for social contacts, companionship, and affection, maintenance of health, and procuring of suitable living arrangements.

The other topics discussed are concerned with changes in the labor force participation, the migration of older people, community adaptation to the aged, organized social life in Florida, the Moosehaven Community of old people, social relations and personal adjustment, life of the retired in a trailer park, the new leisure class, some clinical and cultural aspects of aging, and economic aspects of aging.

W. H. REALS
University College
Washington University

PENSION PLANS UNDER COLLECTIVE BARGAINING, Bulletin 1147 of Labor Statistics, U. S. Department of Labor, Bureau of Labor Statistics, Washington, D. C., 1953, 23 pages, 20¢.

Pension, health, and insurance plans have increased in number and coverage very largely during the last decade. Although employers had sponsored such plans, few union agreements prior to 1940 made provisions for them.

The *Bulletin* consists of three studies of the Bureau of Labor Statistics reported earlier in the March, May, and July, 1953, issues of the Monthly Labor Review. Selected provisions of a representative sample (300) of pension plans under collective bargaining are analyzed.

Part I is a study of vested rights; Part II, compulsory retirement; Part III, types of benefits.

W. H. REALS
University College
Washington University

LIVING YOUR LATER YEARS, by Kenneth Walker, Oxford University Press, New York, 1954, 196 pages, $3.50.

OUR ADVANCING YEARS, by Trevor Howell, Phoenix House Ltd., London, distributed by Macmillan Co., New York, 1953, 192 pages, $3.50.

Such obvious similarities as titles, prices, number of pages, and authorship by British medical men suggest the desirability of a joint review of these two books. Still more significant likenesses, however, also apply to these two volumes. Both were designed for those working with mature people and also for aging people themselves. Both discuss present medical and other "scientific" knowledge of the more important concerns faced by the aging and also by society because of population trends. Both authors present significant facts and suggestions in a pleasing, interesting, effective style.

Dr. Walker, a distinguished surgeon now in his seventies who has been a prolific writer for scientific journals and also has a number of scholarly books to his credit, calls upon his unusual talents and experiences to explain that "there is no phase of life for which preparation is more necessary or more rewarding than preparation for the later years." Unfortunately, the general public shows little interest "in the subject of growing old, for it prefers to forget that this is the lot of all passengers through time." Thoughts of old age are "promptly expelled," since most people "are journeying to a destination none of them want to reach, the bleak forbidding country of the old, and being unwilling tourists they make no provision for their arrival there."

To awaken his readers to essential facts and attitudes, Dr. Walker dwells briefly on many matters. He does not hesitate to draw with "authority" upon the fields of psychology, philosophy, religion, and literary history, as well as to discuss the medical aspects of aging. Some theologians may resent and disagree with certain of his positions in the chapter on "The Religious View of Old Age." Psychologists and philosophers may smile gently or react more violently to chapters on "The Psychological Changes in Old Age" and "The Philosophy of Old Age." But all who read this book will welcome the keen insights and the excellent suggestions of a brilliant surgeon, as he explains how and why "most of us should enjoy life longer than we do."

Dr. Trevor Howell confines himself more to those issues and facts we would expect to be considered by a physician. He "surveys the advances made in recent years in the medical care and rehabilitation of old people." He stresses the growing interest of the younger members of the medical profession in Great Britain with "the *happiness* of their elderly patients, and the increasingly helpful cooperation between doctors, hospitals, civil authorities and voluntary societies." Besides purely medical problems he considers also social issues, drawing upon his experience as director of a Home for the Aged Sick and his work as a consultant physician in charge of a research unit, and as a lecturer on "problems of old age." Although calling attention to many deplorable conditions, he praises the "enlightened outlook of present day housing authorities and Public Assistance Institutions."

Both *Living Your Later Years* and *Our Advancing Years* are praiseworthy contributions. The former is excellent reading for anyone wanting a survey of the entire range of historical background, present issues, and possible solutions to our yearnings to "grow older happily"—for example, an outstanding gift or suggested reading for one of our friends who happens to express interest in this "new subject" of gerontology. More restricted to conditions existing in Britain, somewhat narrower in its coverage of the "many problems of old age," but perhaps also more of a contribution to those who have already done considerable reading and thinking about problems of aging, *Our Advancing Years* is also a significant book.

EARNEST BRANDENBURG
University College
Washington University

BOOKS RECEIVED

Books received since February 1, 1954, are acknowledged in the following list.

Add Life to Your Years, by Ernst P. Boas, McBride Co., New York, 1954, 278 pages, $3.75 (reviewed in this issue, page 365).

Florida's Older People, A Chart Book, Special Bulletin No. 3, December, 1953, Bureau of Economic and Business Research, College of Business Administration, University of Florida, Gainesville, 81 pages, paper bound, 50¢.

How to Be a Woman, by Lawrence K. Frank and Mary Frank, edited by Adie Suehsdorf, Bobbs-Merrill Co., Inc., New York, 1954, 144 pages, $2.75 (reviewed in this issue, page 365).

Living Your Later Years, by Kenneth Walker, Oxford University Press, New York, 1954, 196 pages, $3.50 (reviewed in this issue, page 366).

Mayo Clinic Diet Manual, Second Edition, by the Committee on Dietetics of the Mayo Clinic, W. B. Saunders Co., Philadelphia, 1954, 247 pages, spiral bound, $5.50.

Medical Progress, 1954, edited by Morris Fishbein, Blakiston Co., Inc., New York, 1954, 345 pages, $5.00.

Parental Age and Characteristics of the Offspring, vol. 57, art. 5, Annals of the New York Academy of Sciences, 1954, 22 papers, consulting editor, Leonell C. Strong, 150 pages, paper bound, $3.50.

The Room Upstairs, by Nora Stirling, published for the American Theatre Wing Community Plays by Human Relations Aids, New York, 1954, 46 pages, paper bound, 6 copies $5.00, single copies $1.00.

Survey of Sheltered Workshops, Jewish Occupational Council, New York, 1954, 31 pages, paper bound, $1.00.

INDEX TO CURRENT PERIODICAL LITERATURE

NATHAN W. SHOCK
Gerontology Section
National Heart Institute
National Institutes of Health

The subject categories are those in *A Classified Bibliography of Gerontology and Geriatrics* by Nathan W. Shock published by Stanford University Press, Stanford, California (1951). Only major headings are used and the Roman numerals correspond to those given in the bibliography. In so far as possible, references are classified according to organ systems. Thus most of the material on Geriatrics will be found under the organ system involved in the disease. Cross references are indicated by number at the end of each section. When available, abstract references are given (*B.A.—Biological Abstracts; P.A.—Psychological Abstracts;* and *P.I.—Population Index*). Abbreviations for journals are those used in *A World List of Scientific Periodicals Published in the years 1900-1933*, 2nd Edition. For journals not listed, abbreviations were devised according to the general rules used in the above source. It is impossible to cover all journals and list all papers concerned with aging and the aged. Authors and publishers are requested to call attention to publications or to send reprints to the Gerontology Section, Baltimore City Hospitals, Baltimore, Maryland. The assistance of the Forest Park Foundation, Peoria, Illinois, in the preparation of these materials is gratefully acknowledged.

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See also No. 11480.

BIOLOGY OF AGING

I. CELLULAR BIOLOGY AND PHYSIOLOGY

(includes plants)

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IV. LONGEVITY

(case reports, drugs, heredity, marriage, occupation, and sex differences)

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